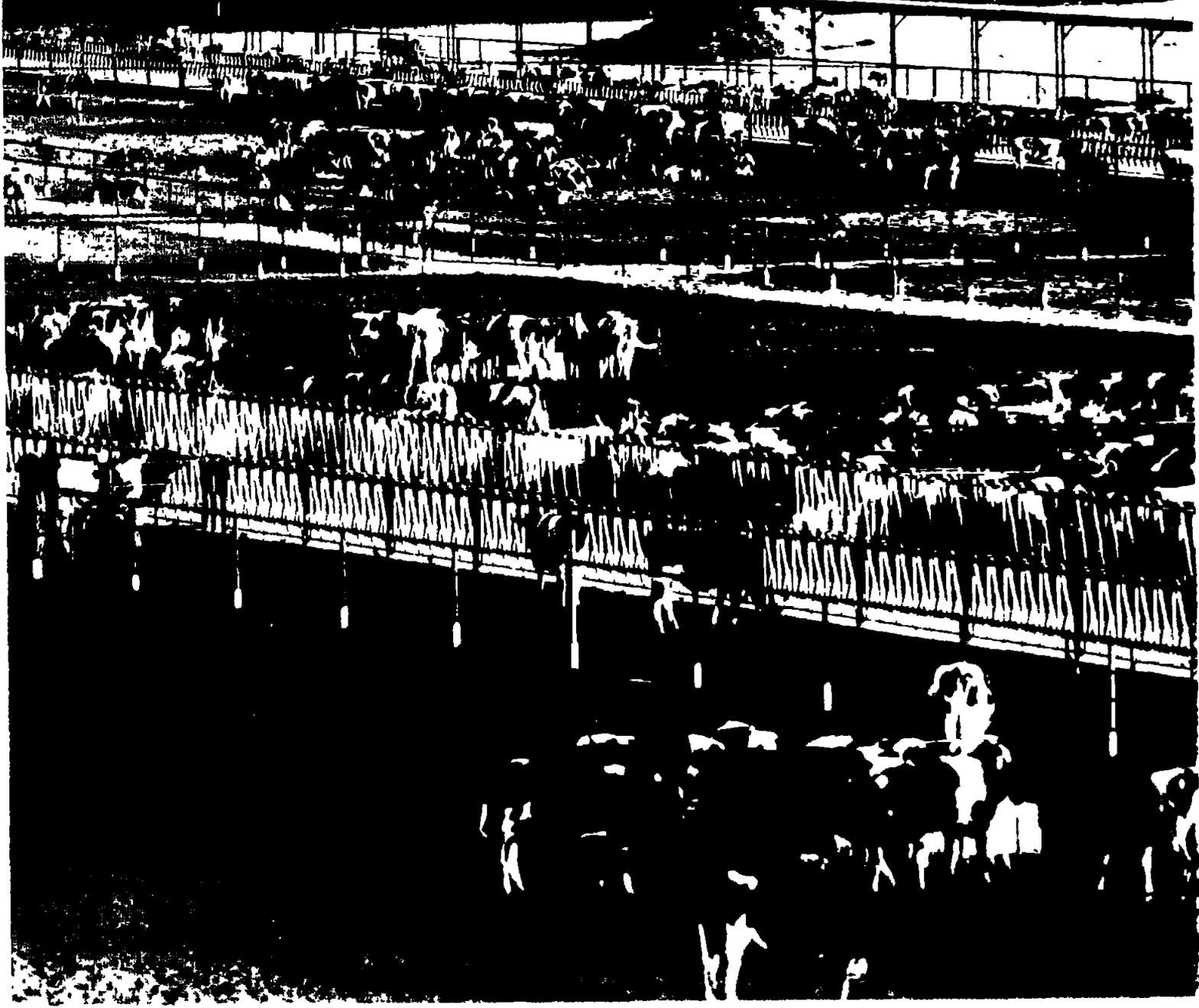


1993
WESTERN LARGE HERD
MANAGEMENT CONFERENCE
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LAS VEGAS NEVADA



1993 WESTERN LARGE HERD DAIRY MANAGEMENT CONFERENCE

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WESTERN LARGE HERD DAIRY MANAGEMENT CONFERENCE



April 22-24, 1993
Las Vegas, Nevada

Planning Committee Members

Dennis Armstrong,
University of Arizona

Mike Gamroth,
Oregon State University

Don Bath,
University of California

John Smith,
New Mexico State University

Ruth Blauwieckel,
Washington State University

Bill Wailes,
Colorado State University

Ron Bowman,
Utah State University

Chris Woelfel,
Texas A&M University

Ed Ficz,
University of Idaho

Leon Weaver,
University of California

**1993
WESTERN LARGE HERD
DAIRY MANAGEMENT
CONFERENCE SCHEDULE**

**Thursday Morning, April 22, 1993
John Smith, New Mexico State University, Chair**

**9:30 — Welcome
Basil Eastwood, Program Leader, USDA Extension Service,
Washington, D.C.**

**10:00 — “Environmental Modifications To Reduce Heat Stress”
Dennis Armstrong, University of Arizona**

**10:35 — “Milking Systems For Large Dairy Farms”
Dr. Steve Spencer, Pennsylvania State University**

**11:10 — “Financial Planning For Expansion Or Renovation”
Dr. Gayle Willett, Washington State University**

11:45 — LUNCH ON YOUR OWN

**Thursday Afternoon, April 22, 1993
Ruth Blauwleckel, Washington State University, Chair**

**1:00 — “Non-Antibiotic Treatment For Mastitis”
Dr. Walt Guterbock, University of California**

**1:35 — “Management Of The Post-Partum Cow”
Dr. Frank Garry, Colorado State University**

**2:10 — “Records For Dairy Production & Quality Assurance”
Dr. Leon Weaver, University of California**

2:45 — BREAK

Dean Faulk, University Of Idaho, Chair

**3:00 — “Heat Detection Aids”
Dr. David Marcinkowski, University of Maine**

**3:35 — “Antibiotic Testing Programs”
Dr. James Cullor, University of California**

**4:10 — “Immunology And Vaccination Programs”
Dr. Vic Cortese, SmithKline Beecham Animal Health**

**4:45 — “Effectiveness Of Premilking Udder Preparation
Practices On Milk Quality And Udder Health”**

Dr. David Galton, Cornell University

5:30-7:30 — Reception. Hosted & cash bars available.

Friday Morning, April 23, 1993
Ron Bowman, Utah State University, Chair

8:00 — “Should A Dairyman Have A Heifer Program?”
Gary Genske, Genske, Mulder & Co. CPAs, Chino, CA

8:35 — “When Is An A.I. Program Profitable?”
Dr. Ben McDaniels, North Carolina State University

9:10 — “Contract Raising Of Heifers”
Ed Fiez, University of Idaho

9:45 — BREAK

Wally Taylor, Utah State University, Chair

10:00 — “Calf Housing Effects On Stress And Health”
Dr. Carolyn Stull, University of California

10:35 — “Manure & Waste Water Management
Systems For Open Lot Dairy Operations”
Dr. John Sweeten, Texas A&M University

11:10 — “Nitrogen Utilization & Cropping”
Dr. James Moore, Oregon State University

11:45 — LUNCH ON YOUR OWN

Friday Afternoon, April 23, 1993
Bill Walles, Colorado State University, Chair

1:00 — “Free Trade Agreements' Effect
On The U.S. Dairy Industry”
Tom Camerlo, National Milk Producers Federation

1:35 — “European Milk Quota System:
Success Or Failure?”
Malcolm Stansfield, University of Reading, England

2:10 — “Farm Organization & Productivity”
Dr. Guy Hutt, University of Southern Maine

2:45 — BREAK

Ellen Jordan, Texas A&M University, Chair

3:00 — “Large Herd Record Analysis”
Dr. Mike Tomaszewski, Texas A&M University

3:35 — “Great Employees?
It Depends On The Manager”
Dr. Rick Bennett, University of California

4:10 — “Barriers To Communicating With Employees”
Dr. Bernie Erven, Ohio State University

4:45 — “Veterinarian-Dairyman Intervention”
Dr. Tom Fuhrman, Arizona Veterinarian

5:20 — ADJOURN

Saturday Morning, April 24, 1993
Chris Woelfel, Texas A&M University, Chair

8:30 — “Feed Additives”
Dr. Mike Hutjens, University of Illinois

9:05 — “Economics Of Forage Quality”
Dr. Don Bath, University of California

9:40 — “Hot Weather Feeding”
Dr. J. Tal Huber, University of Arizona

10:15 — “Water Quality”
Dr. David Beede, University of Florida

10:50 — “Commodity Feeding”
Mike Gamroth, Oregon State University

11:25 — CLOSING REMARKS & EVALUATION

Environmental Modification To Reduce Heat Stress

Dennis V. Armstrong
Department of Animal Sciences
The University of Arizona
Tucson, Arizona

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Environmental Modification To Reduce Heat Stress

Dennis V. Armstrong

Department of Animal Sciences
The University of Arizona
Tucson, Arizona

Introduction

Summer depression in milk production and reproductive performance is a very serious dairy industry problem in hot semi-arid and arid climates of the world. When the temperature exceeds 100°C even with low humidity, the microclimate is above the comfort zone for high milk production according to Bianca (1962) Hahn (1976), and Sainburg (1967). Stress occurs whenever the temperature humidity index (THI)* exceeds 72. A THI of 72°F also occurs at the following temperature (F) and relative humidity (RH) (75°F and 80% RH); (88°F and 5% RH) and (82°F and 20% RH) all common temperature and relative humidity in western United States. Figure 1 by Wiersma (1990) shows the effect of heat stress on dairy cows from THI for a mild stress to a THI that causes dead cows. A high producing dairy cow exposed to long periods above the comfort zone reacts in several ways to retain comfort (1) seek out shade (2) increase water intake (3) reduce feed intake (4) stand rather than lying (unless wet ground is available) (5) increased respiration rate (6) increased body temperature (7) and excessive saliva production.

Shades

Shade for dairy cattle is considered essential to minimize loss in milk production and reproduction efficiency. Trees are the most effective shade as they combine protection from the sun with the radiation sink effect created by the cool leaves evaporating moisture. Wood, asbestos or palm tree branches are effective shading material. Sheet steel and aluminum are the most popular because of cost, length of life and low maintenance cost. Slatted shade is less effective than total shade. Kelly (1958) found that slatted snow fencing with approximately 50% openings was only 59% as effective as new aluminum sheeting for shading ground. Welchert et al. (1965) compared solid shade vs. slatted shade on a dairy farm in Arizona. Milk production for the solid shade cows averaged 3.1 lbs/day higher than for cows under a slatted shade, demonstrating the necessity for solid shade in hot-arid climates.

The location and size of the shade in dairy design is important. A mature dairy cow (lactating or non-lactating) requires from 38-48 sq. ft. of shade. Less than 38 ft can result in udder injury as cows crowd together, and excessive shade over 48 ft has no benefit as cows tend to group together under the shade. Shades should be 11-14 ft high to decrease the amount of reflected solar radiation from the shade roof to the cow. The orientation of the shade should usually be from north to south to allow the area under the shade to be exposed to the morning and afternoon sun to keep the ground dry.

(*: Temperature-humidity index incorporates both temperature and humidity index and is defined by the equation $THI = (\text{Dry-Bulb Temp. } ^\circ\text{C}) + (0.36 \text{ dew point Temp. } ^\circ\text{C}) + 41.2$.)

Under extremely high temperature conditions, it may be preferable to use an east-west orientation. However, this orientation will require additional ground maintenance to keep the surface dry. In either case, location of the shade in the center of the corral or pen will help in the distribution of manure. Ground maintenance by dragging the wet material out from under the shade and replacing it with dry is necessary to help keep the cows dry and clean.

Holding Pen Cooling

It is common to confine dairy cattle for 15 to 60 minutes in a holding pen adjacent to the milking parlor prior to milking. Most holding pens add to the heat stress in summer months because the pens are crowded and hot. In most hot climates, cows are sprayed from below to clean the udder. With this practice, the holding pen becomes very hot and humid. To improve this environment, overhead sprinklers (not foggers) and large fans that bring in drier outside air were installed and tested by Wiersma and Armstrong (1983). The sprinklers run continuously with low volume (3 gal per hour) sprinklers. Large fans (48 in) are located above the cow, mounted at a 30° angle from vertical so that the air blows downward and around the cow. Air flow per cow was approximately 1000 cfm/per cow. Daily high temperature for the experimental period ranged from 81 to 115°F. Cows were milked three times per day. Body temperature of cows was determined by measuring milk temperature during milking. Body temperature in cows with access to the spray/fan system in the holding pen were about 3.5°F lower. The milk production averaged 1.7 lb higher for the cooled cows for the summer months. This represents a rather modest increase, but the return over investment and operating cost was realized in less than one summer season.

Present installation in southwestern United States and northern Mexico follow the majority of the specifications which were used in this experiment. Thirty and thirty-six fans are being used because they are more readily available. In the 1983 trial the direction of the air movement was from the milking stall area out of the parlor. Some dairies have installed the fans to blow from the wash/holding pen area into the parlor. Both methods will cool the cows when both fans and spray lines are on. The only disadvantages are that on the days just before the hot summer (April-May) or after (Sept.-Oct) or at night when the spray lines are not used, even then blowing the air out of the parlor can reduce cow stress in the wash-holding pen area. The majority of dairymen in western United States should consider holding pen cooling.

Exit Lane Cooling

To increase the cooling period past the milking period, parlor exit sprinklers should be installed in the exit lanes. If the cow enters the corral with a wet body surface the moisture will evaporate thus cooling the cow for an additional 15-25 minutes depending upon weather conditions. Although this may seem like a short period of the total time for the cow it can contribute to cow comfort. On the majority of dairy farms that have both holding pen cooling and exit sprinklers, instead of the cow returning immediately to the shade, the cow will go to the feed manger and eat.

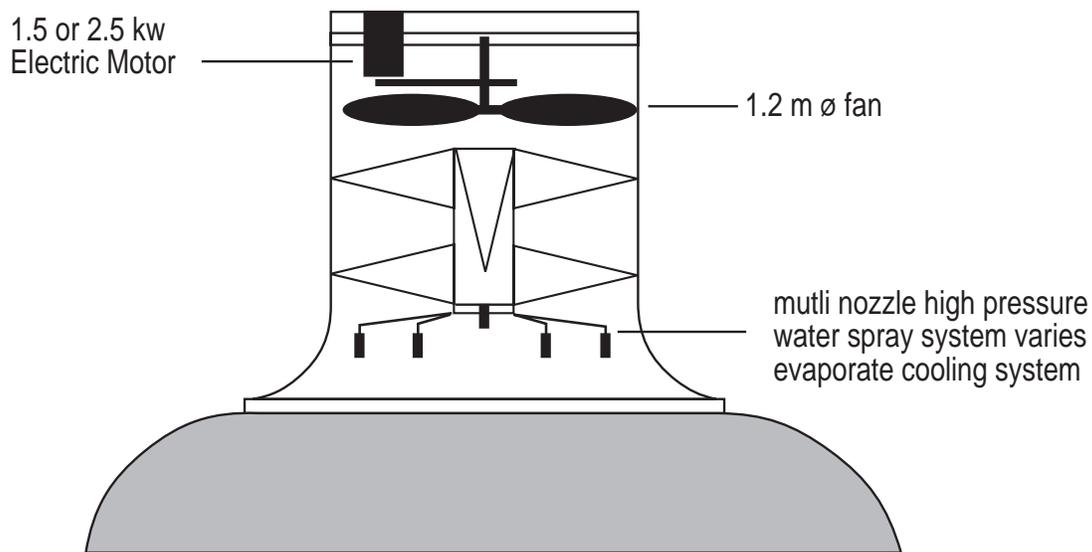
The installation of exit lane sprinklers include nozzle (approximately 3-4 nozzles) with a delivery of approximately 8 gallons of water per minute (ordinary shower sprays are excellent) at 35-40 P.S.I. pressure. This will drive the water into the hair coat. Common control switch to control the water spray include electric eyes, wands or leaf gates. The switch activates a normally closed solenoid valve so that the nozzles eject a spray on each cow as she exits. The nozzles are located one foot behind the control switch mechanization so a cow is sprayed just after her head extends past the area of the spray pattern. This avoids spraying water in the ear cavity. The nozzles are

arranged to spray from the top and side only. If installed properly the water does not wet the udder or teats, therefore, not interfering with the post-milking teat dip.

Corral Shade Cooling

Improvement in milk production and reproductive efficiency have been demonstrated for dairy cows in open corrals with access to evaporative cooling under shade in southwestern United States and Saudi Arabia. Wiersma and Stott (1962) used a horizontal pad system to increase milk production and Stott et al. (1972) improved the reproductive performance with the same kind of horizontal-pad evaporative cooler. The benefits of evaporative cooling are not limited to semi-arid regions. In Florida with a humid climate Taylor et al. (1986) found that air temperature was reduced using an evaporative pad system. Although the evaporative pad system was effective in reducing the stress on dairy cows, its maintenance was viewed by dairy owners as a time consuming and costly endeavor. Consequently its adoption by the dairy industry was slow.

In 1981, a company in Mesa, Arizona, (Korral Kool) developed an evaporative cooling package that could be mounted in a conventional corral shade. (Figure 1) The system featured a fan driven by a 1 HP kw motor which drives the air (425 m³/min through vanes located directly under the fan creating a cyclonic motion in the descending air stream. Water nozzles inject atomized water under high pressure (1400-5000 kPa). The microscopic water droplets are discharged at 55 microns diameter but evaporate as they descend toward the ground. Some of the minute particles collect and stay on the hair of the cow but do not wet the ground. A fiberglass flare is designed to disperse the cooled air under the shaded area. A synthetic canvas curtain is suspended from the edge of the shade on the side of the prevailing wind to semi-confine the cooled air. The entire system is automatically controlled in response to air temperature and wind velocity. Modifications have been made since 1984 to increase the air flow to 800 m³/min and the water injection system has been automated to vary the water spray output as the water holding capacity of the air changes. The increased



water use increases the effective cooling available to the dairy cow. One unit is sufficient for 13-15 mature dairy cows.

What type of cooling will be cost effective is the major factor when considering dairy cattle cooling in the corral area. In areas with a long summer May through September (150 days) one type of corral cooling may be more cost beneficial than another. If the summer period of hot days is shorter, 100 days or less, then other types or no corral cooling would be the correct decision. What stage of the cow's life should the cow be cooled with corral cooling also is an important decision. Is it only early lactation, mid or late lactation or the dry period? Table (1) is based upon the results of research trials in southwestern United States, Mexico and Saudi Arabia. Some of the figures for different temperature responses being estimated. In calculating the total benefit from corral shade cooling, the milk production has usually been one-half of the total benefits which would include improved reproduction performance, less culling percentage and fewer sick cows and dead cows during the summer months.

Summary

Some form of dairy cattle cooling would benefit the majority of dairy farms in western United States. For a dairyman to choose which cooling method he should consider the following order should be of benefit:

1. Solid shade for all milking and dry cows 2. Holding pen cooling 3. Exit lane cooling 4. Corral shade cooling 5. Feed line cooling 6. Covered feed line

Improving the comfort of dairy cattle as milk production increased is necessary if you are to receive the maximum benefits from your nutrition, genetic and management programs.

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Table 1. Estimated milk production response for different types of cooling systems when compared to no cooling, in climates with an average day time humidity less than 30%.*

Different stage of lactation	(3 HP Units) & daily high temperature	Evap. Cooling	Spray & Fan
Early Lactation	> 85lb/day	lbs of milk	lbs of milk
	>105°F	16.5	8.8
	95 - 104	13.2	7.0
	<94°	11.6	6.2
Mid-lactation	65 - 85lb/day		
	>105°F	14.2	7.7
	95 - 104	11.4	6.2
	<94	10.0	5.4
Late lactation	<65lb/day		
	>105°F	12.3	7.1
	95 - 104	10.0	5.7
	<94	8.6	5.0
Dry Cows: milk production first 120 days of lactation (total lbs of milk)			
	>105°F	4.5(540)	3.0(360)
	95 - 104	3.0(360)	2.0(240)
	<94	2.0(240)	1.3(156)

*: Based upon research projects in southwestern United States, Mexico and Saudi Arabia. (See reference Numbers 1, 2, 3, 4, 8, 9, 11 and 14).

1993 WESTERN LARGE HERD MANAGEMENT CONFERENCE
NOTES

Milking System Design for Large Herds

Stephen B. Spencer
Professor of Dairy Science
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Milking System Design for Large Herds

Stephen B. Spencer
Professor of Dairy Science
Penn State University

Milking system design has changed dramatically in recent years. Large parlors of up to 100 milking units have been primarily responsible for these advances in design. The U.S. leads the world in the design of highly efficient, modern and attractive facilities.

The industry has advanced with sophisticated component design, however, fundamental systems design has lagged in development. For example, most system cleaning designs have evolved from field experience and only recently have basic cleaning parameters been investigated.

Vacuum pumps: One area of controversy that has existed for many years is that of the required vacuum pump capacity. Guidelines are often promulgated without experimental evidence of performance. The required pump capacity is clearly governed by the amount of air usage at the specified operating vacuum for milking and/or washing. Usage requirements (10) are shown in Table 1.

Smith et al. (9) determined washing usage on 11 farms in California to range from 2.3 to 7.8 scfm, while average air usage during milking was .2 to 1.15 cfm. Spencer (8) determined milking vacuum requirements which included generous allowances for operator usage and by-pass air for regulators having substantial requirements, Figure 1.

Pipe size: Pipe sizing is well developed from a design standpoint but the available data is not utilized as much as is desirable. Vacuum head loss tables are available to precisely determine size based upon air flow, pipe diameter, length and number of fittings. Table 2 lists those losses from which calculations can be done for either analysis or design purposes. A vacuum head loss ranging from 0.25 to 0.5" Hg is recommended, while a reasonable maximum of 0.75" Hg is suggested. Table 3 lists the equivalent lengths of straight pipe to include in head loss determinations. Table 4 is derived from tables 2 and 3 which gives a quick, easy reference to pipe size.

Our observations indicate that the pipe size from the regulator to the balance tank is often too small. Any piping system should be designed for full pump capacity from the regulator to the pump since this is the area of greatest air flow. It is also suggested that full pump capacity should be accommodated to the receiver assembly, since this may also be the regulator location.

Milk pipes: Recent research indicates that milk pipe size recommendations are in serious need of review. Milk pipe size is a dichotomy of design in milking and washing requirements. Most authorities agree that stratified flow is desired during milking, while plug or slug flow is necessary to clean during the wash cycle, see flow patterns Figure 2. Measuring slug flow can be determined by monitoring milkline vacuum. A vacuum drop of 0.6" Hg from mean milking vacuum is a reliable indicator of slug formation (4).

Spencer and Bray (12) determined that the carrying capacity of 3 inch milk lines exceed those of the 3A recommendations for milking. Length of pipeline has little effect upon carrying capacity (7) while the unit attachment rate has a significant bearing upon the required diameter (2). Pipeline slope has a significant affect upon pipeline carrying capacity (5) as does transient air admission. The effect of slope can be noted in table 6.

Vacuum level: Operating vacuum recommendations are also in need of review. Manufacturers are often reluctant to specify an operating vacuum since no precise data are available. Our studies indicate that there is an interaction of liners and vacuum, therefore liners should be optimized to operating vacuum. Liner slip rate increases as vacuum is lowered from 15" Hg. It is interesting to note that the recommendation in Florida for vacuum setting is 15" Hg, "No more, No less" (1). Our guide to setting system vacuum is shown in table 5.

It is not uncommon to hear that vacuum should be set at the teat end. Consider that the vacuum at the teat end is cow dependant, that is, vacuum varies at the teat end depending upon milking rate. There are other variables such as height of pipeline, hose length and size, air vent rate (11) and type of automatic detacher. The best that can be done is to set system vacuum and the vacuum at the teat end has to fall where this combination of factors dictate. Vacuum fluctuation is an even more complex issue since milk and air are in two phase flow from the milking unit to the milk pipe. Many variable variations develop due to this phenomena. Thus, vacuum settings based upon teat end vacuum are difficult, at best.

Cleaning: No design is complete without considering the cleaning performance of a milking system. It is generally accepted that slug flow is required during the wash cycle so that the wash solution reaches all milk contact surfaces. The required air flow depends upon pipe diameter, ranging from 30 to 55 cfm on a 3-inch line (6). A larger pump capacity above the maximum suggested will not improve cleaning performance. A crucial factor in proper slug maintenance is the air injector timing. As a guide, dividing the length of line to be cleaned by 25 will give the approximate time of air injector open time. The air injector should remain open until just before the slug reaches the receiver. Excessive air volumes admitted by the air injector may break down the slug after its' original formation. Slug velocities range from 23 to 32 ft/s.

Air injectors are often installed on the unit wash lines. This may force jetter cups off the liner mouthpieces and result in inadequate cleaning. In our experience, the air injector mounted in the milk room on the wash supply pipe to the main milk pipe yields the best results. A continuous air bleed to the unit washers will usually provide adequate turbulence up to 12 units (Double 12 parlor) and reduce the total wash solution volume. Parlors that are larger than a double-12 may require a wash pump to supply enough water to the units and achieve an even distribution of water among units. An electronic recorder to monitor slug passage or a visible pipe section mounted in the milkline prior to receiver entry will aid in determining washing performance.

The future: In the future it is desirable to improve systems design using known engineering principles. More research, especially with regard to cleaning, is needed in order to account for the wide variety of systems. Potential exists to greatly improve energy use for vacuum systems. Research at Cornell University (3) has shown that adjustable speed/dual

vacuum systems can reduce energy use by 50% or more. Research has already shown that the re-use of detergents is possible.

In Europe, large diameter milk pipes (8") are in use without receiver assemblies. They are cleaned with internal spray rails. We have only begun to use the marvels of electronic data capture. On-line conductivity measurements, fat, protein, and somatic cell counts are possible. Perhaps a pregnancy specific protein could determine pregnancy status. The use of robots may be economically feasible as conditions change. The use of shielding to protect fragile components will no doubt increase. Under-the-platform piping to clear the operator area and protect electronic meters will probably increase in popularity. The rate of change that has characterized the last decade is likely to accelerate.

Table 1: Vacuum usage of events during milking.*

Event	Cfm usage, ASME
Remove unit	.0 to 4.1
Put on unit	.1 to 8.0
Machine strip	.1 to 3.8
Liner slip	4.0 to 8.0
Unit fall off	20.0 to 50.0

* From (10).

Table 2: Vacuum drop per 100 feet of PVC pipe(inHg).*

Cfm, ASME	2 inch	3 inch	4 inch
30	.25	.04	—
40	.41	.06	—
50	.60	.08	—
60	.75	.12	—
70	1.03	.15	—
80	1.14	.19	.06
90	1.43	.24	.07
100	1.71	.29	.08
150	—	.61	.16
200	—	1.10	.26
250	—	—	.39
300	—	—	.54
350	—	—	.71
400	—	—	.91

* At 15 inHg. vacuum head.

From Spencer, S. B. and G. A. Mein. 1991. ASAE paper #913509

Table 3: Equivalent lengths of straight pipe (in feet) for various pipe fittings and pipe diameters.

Nominal pipe size, inches	Fitting (ID,in.)		
	2	3	4
Elbows:			
45° standard	1.5	2.5	3
90° med. radius	3	4	6
90° short radius	6	10	12

T-pieces:				
Through flow	3	4	6	
Side flow	7	9	15	
Sweep, side flow	3.5	5	7	
Expansion, contraction and tanks:				
Receiver, trap	10.5	14	22	
Contraction — tank to pipe	3.5	5	7	
Expansion — pipe to tank	7	9	15	

Table 4: Recommended minimum pipe sizes (in inches) for the main airline of milking systems (11).

Vacuum pump capacity Cfm-ASME	(Length of main airline, in feet)				
	20	40	60	80	100
	Nominal pipe diameter, inches				
50	2	2	3	3	3
60	2	3	3	3	3
70	3	3	3	3	3
100	3	3	3	3	3
150	3	4	4	4	4
200	4	4	4	4	4
250	4	4	4	6	6
300	4	6	6	6	6
350	6	6	6	6	6
400	6	6	6	6	6

Table 5: Suggested operating system vacuum (10).

Type of system	Inches of mercury
High line	14.0 to 15.0
Low line	13.0 to 14.0
Mid line	13.5 to 14.5

Note: Operating vacuum may depend upon liner collapse resistance characteristics. It is suggested that liners with low resistance to collapse be used at the lower end of the ranges above, while high resistance to collapse liners be used at the high end of the range. Low resistance liners are defined as requiring less than 4"Hg differential to liner wall touch point while high resistance liners are greater than 4" Hg pressure differential to liner wall touch point.

Table 6: Effect of slope and transient air admission on number of units per slope (4).*

Milkline size	Number of units per slope			
	Slope			
	0.5%	1.0%	1.5%	2.0%
2 inch	2	3	4	
5 2.5 inch 4	6	10		
3 inch	6	10	16	24

(*: Based upon an average maximum flow rate of 12 lbs. per minute and transient air admission of 3.5 scfm.)

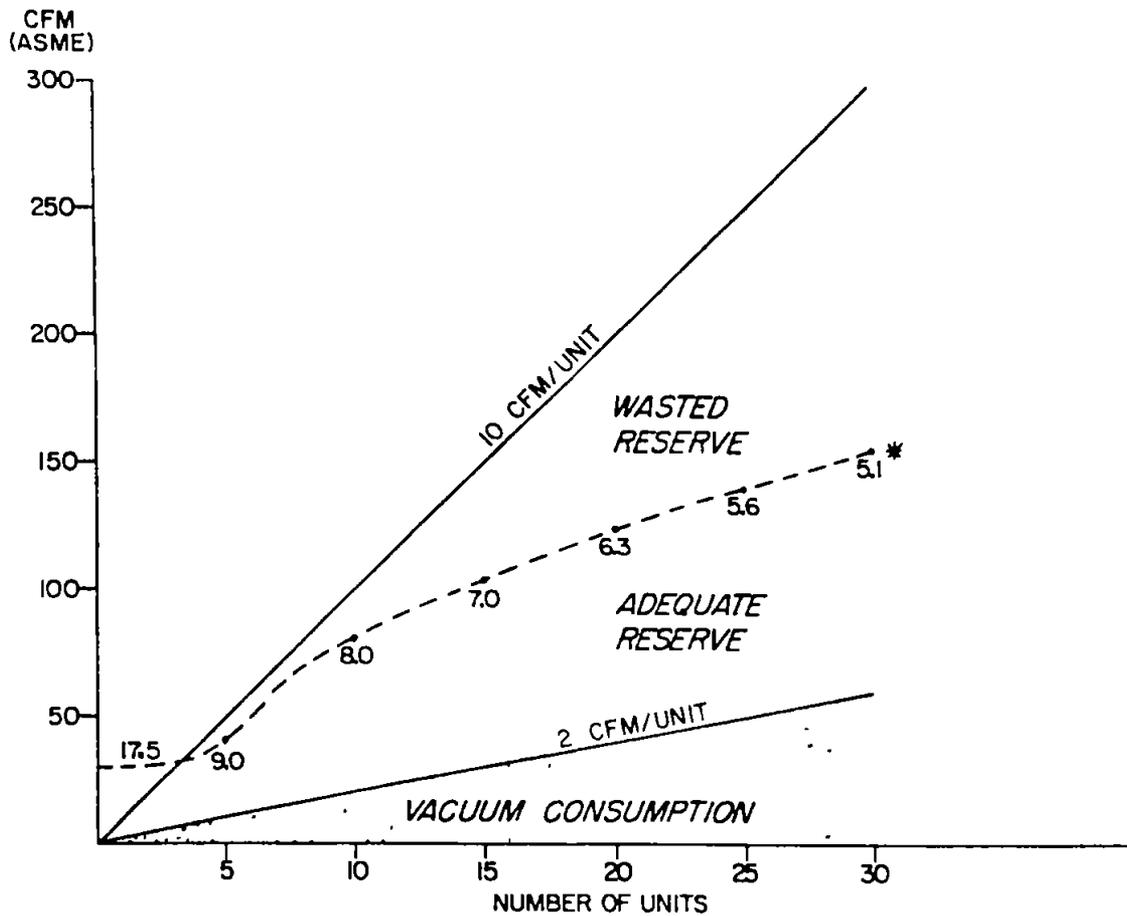
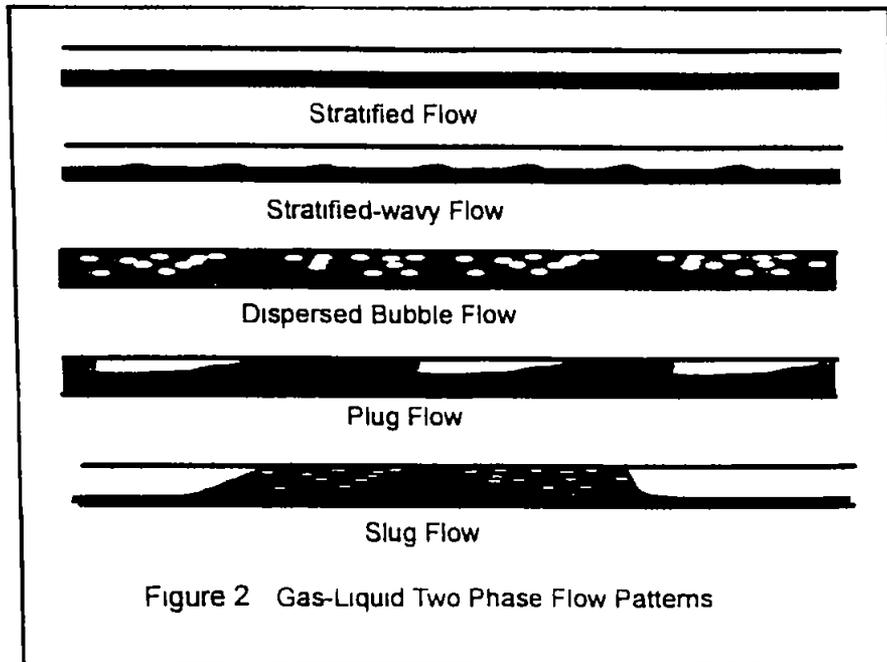


FIGURE 1 - VACUUM RESERVE AND UNIT CONSUMPTION

* VALUES ARE CFM/UNIT



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Financial Planning For
Expansion And Other
Major Adjustments

Gayle S. Willett
Extension Economist
Washington State University

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Financial Planning For Expansion And Other Major Adjustments

Gayle S. Willett

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Introduction:

Herd expansion and other major business adjustments are a common event for many dairy farm managers. The strength of the incentives for expansion can be underlined by noting that over the 10-year period, 1982-1991, U.S. dairy operations with more than 100 cows grew from 6.1% to 11.5%, while the cows represented by these units increased from 34.7% to 45.4% of the nation's dairy herd. The reasons for the popularity of expansion and the increased concentration of milk production into fewer but larger herds are numerous.

The continuing emergence of new, capital intensive technology with strong economies of size features has been a principal reason. Such technology (e.g., improved parlors, feeding, and waste handling systems), once adopted, may not be fully utilized. However, through herd expansion, fixed costs including depreciation, interest, and property taxes can be spread over more hundredweights of milk, resulting in lower per unit costs. Additionally, improved labor efficiency has been affiliated with most new dairy technology. In some cases, growth has occurred to more effectively utilize management resources. Finally, net income can be increased by expansion when the per-hundredweight milk price and cost relationship is favorable and constant at different levels of production.

Expansion has not always resulted in higher income. Many dairy farmers have experienced financial difficulty because of a decision to expand. In some cases, the timing has been unfortunate in that profit margins fell due to unanticipated rising costs, falling milk prices, and/or declining cow productivity. Others found they were unable to cope with the labor and management challenges associated with a larger business. Some used debt that was excessive, over priced, and/or inappropriately structured.

It is widely accepted that effective planning can contribute to better decision making about whether to expand or make other major adjustments in the business. The objective of this paper is to review selected management concepts relevant to effective financial planning and analysis. While the comments will focus on expansion planning, most are also appropriate when planning for other major business adjustments (e.g., change in milking, feeding, housing or waste handling system). A herd expansion example is used to illustrate the application of relevant management concepts.

Basic Planning And Analysis Considerations:

The starting point in considering herd expansion is reaching agreement among the owners and management that a larger operation is a desirable goal. Expansion often implies added financial risk. It may also mean increased personal stress due to heavier and perhaps new management responsibilities. If the relevant people are not willing to accept these challenges, no amount of planning and analysis will assure a successful expansion program.

Another prerequisite for successful expansion is the absence of major business weaknesses. Pre-expansion problems often become post-expansion crises. Related to this is the need for good records and their use in identifying weaknesses. This means a record system is in place that permits the timely preparation of a complete and accurate balance sheet, accrual income statement, statement of cash flows, statement of owner equity, enterprise reports, and a periodic and trend analysis of business profitability, liquidity, solvency, repayment capacity, and financial efficiency. Without this kind of financial information, the manager is handicapped in developing the understanding and control of the dairy business that is essential to effectively managing a larger operation.

With these prerequisites in mind, the next concern is planning the proposed expansion. Comprehensive planning is needed to convince the owner(s), management, and those outside of the business (for example, potential lender and/or outside equity investor) that the proposal is financially acceptable. Mistakes in decision making about outlays for capital assets (e.g., cows, buildings, equipment, and land) can have devastating and long-standing consequences, since they are often large, heavily debt financed, long-term, and made in an increasingly volatile economic environment.

The options for controlling a capital investment are quite limited once the funds have been committed. Thus, the key to improved investment decision making is identifying expansion projects with the potential for acceptable financial performance before the capital is committed. This can be done by subjecting the proposed investment to thorough financial planning and analysis. These efforts can be viewed as occurring in two phases: (1) long-range, and (2) transitional.

Long-Range Planning

The task with long-range planning is to evaluate financial performance when the expansion program has been fully implemented and is in full stride. This includes a financial analysis that addresses three key questions about the expansion proposal: (1) Will it be profitable?, (2) Will it cash flow?, and (3) Are the risks acceptable? The overriding concern about expansion is whether acquiring control of additional resources will generate a profit that is sufficient to compensate for the added risks. Since expansion generally requires a major capital investment, profitability needs to be measured in terms of capital performance (for example, rate of return on the added investment). Expansion may also imply an increase in operator labor and management and it is important to determine if sufficient income accrues to these personal resources.

Although profitability and cash flow are highly correlated, acceptable performance for one does not necessarily imply the same for the other. Thus, there is a need to analyze both. The intent of a cash flow analysis is to determine if the expanded business will generate sufficient cash receipts to meet its cash obligations in a timely manner without disrupting the operation. More specifically, one should determine if funds are available to pay operating expenses, income and social security taxes, retire term (over one-year maturity) debt, replace depreciable assets as they wear out, maintain a contingency reserve, and provide an acceptable living standard.

Risk is another issue that should be addressed by a long-range financial analysis. The ability of the business to withstand risk is referred to as its solvency position, measured by net worth and percent indebtedness (total debt ÷ total assets). A higher net worth and a lower percent indebtedness implies stronger solvency and an increased ability to withstand risk.

In addition to identifying the impact of expansion on net worth and percent indebtedness, risk may be evaluated by noting the effect of adverse events on projected profitability and cash flow. Several analytical techniques are available to evaluate these risks. One approach is to complete a profitability and cash flow analysis under a most likely set of assumptions for high risk variables (e.g., milk price, feed cost). Results may then be subjectively evaluated in terms of whether or not performance is sufficiently strong to compensate for the various risks. Another technique is a sensitivity analysis wherein you first do a base analysis assuming the most likely outcome. The analysis is then rerun adopting more pessimistic values for the important high risk variables. In this manner, the vulnerability of the expansion program to downside risk can be evaluated. Risk may also be evaluated by calculating break-even values for the more important, yet high risk variables. We may, for example, determine the milk price needed to meet our profit objective or to realize an acceptable cash flow. Once the break-even value is known, the investor must only determine whether the variable in question is likely to be greater than or less than the break-even rate. That decision involves less risk than basing the analysis entirely on a most likely value.

Transitional Planning

Planning and budgeting necessarily require specification of a point in time for which the operation is to be evaluated. Quite logically, the manager's initial concern will be with the business as it would be expected to perform at the time a new equilibrium is reached, i.e., when new facilities are fully utilized and major adjustment problems have subsided. This type of planning requires analyzing the business two to three years from the time the planned change has been implemented. The above discussion has focused on this long-term variety of planning. Consequently, the problems associated with making the transition from a smaller to larger herd were largely overlooked.

Additional planning efforts are needed to focus on the transitional period. For dairy farmers making a major expansion and or reorganization of their business, subsequent adjustment problems can be expected. While maintaining production levels during an expansionary period is partially a function of the existing herd's productivity and the quality of cows added, the initial managerial difficulties of properly caring for more cows may result in at least a temporary drop in per-cow milk production. Production decreases may result from problems encountered in such critical areas as feeding, breeding, and maintaining herd health. In addition, a change in work routines may lead to temporary labor productivity problems.

The strong likelihood of substandard business performance during the transitional period implies that there will likely be cash-flow problems not revealed by long-term budgeting. Careful budgeting of expected cash inflows and outflows during the first one to two years will be needed to identify additional credit needs. By knowing the extent of cash deficits in advance, the manager can do a more effective job of planning for credit needs, thus reducing the risk of experiencing loan payback problems and perhaps, failure to reach long-term goals.

The final phase of expansion management is monitoring and controlling the business as the expansion program is implemented. Records and transitional period cash flow projections are key control tools. A comparison of actual cash flows with projected cash flows as the transition period unfolds may reveal discrepancies between the two. The manager is, therefore, in a position to quickly address an emerging problem before it becomes a crisis threatening the entire expansion program. Adopting appropriate risk control strategies is another means of reducing the impact of unexpected adverse developments. The exact nature of these strategies will vary with the type of dairy farm and expansion program.

Case Farm

Current Situation: The following discussion uses a case farm to illustrate how a proposed expansion program may be analyzed. H. & O. Stein is a 400-cow dairy operated as a general partnership with the parents and an older son and daughter-in-law as partners. The dairy includes 120 acres that are primarily used for barns, corrals, and other facilities. All feed is purchased and replacement heifers are contract raised off the dairy. Average annual milk production has been about 21,000 pounds per cow during the past two years.

A second son and his family have expressed an interest in joining the partnership. The son wants to work full-time with the dairy business. Thanks to 25 years of hard work and good management, the Stein partnership is financially stable. However, the business is not large enough to provide adequate financial support for another family. Thus, if the second son joins the business, expansion will have to occur.

After several family discussions, agreement has been reached to allow the son and his family to join the business, provided a proposed expansion program is financially sound. The proposal is to add 200 cows, replace the old double-12 herringbone parlor with a new double-16 herringbone and expand or remodel several other facilities (i.e., waste handling, housing, parlor building, feed storage, and milk storage). Approximately \$260,000 is needed to purchase 200 head of cows and springer heifers. Estimates submitted by contractors and suppliers indicate an additional \$248,000 is needed to make the facility adjustments. A preliminary discussion with the Stein's lender suggests that the lending institution may be willing to finance expansion with a \$508,000 loan fully amortized over seven years at 9% interest. However, the lender wants to see substantial financial documentation, including an analysis of the investment, before making a final decision on the loan, including the interest rate and the repayment period. Finally, the Steins feel that the expanded business should generate about \$100,000 to support the three families.

Long-Range Financial Analysis

The Steins' initial concern is whether financial performance of the 600-cow business will be acceptable once the expansion program is fully implemented and transitional problems, if any, have subsided. To conduct a financial analysis of the expansion proposal, the Steins opt to use a computerized whole-farm budgeting tool called FINLRB. This program was developed by faculty at the University of Minnesota and is available through Cooperative Extension in many states (1). A summary of the financial analysis which represents a typical year after the expansion program has been fully implemented, appears in Table 1. As indicated, the analysis addresses three aspects of financial performance: (1) profitability, (2) cash flow, and (3) solvency (or risk).

Expanding from 400 cows to 600 cows is projected to increase annual gross cash receipts from \$1,082,000 to \$1,623,000 (line 1). This estimate is based on a herd average of 21,000 pounds of milk and a milk price of \$12 per hundredweight for both herd sizes. Also included are cull cow (30% annual herd turnover) and bull calf sales. Cash operating expenses are expected to rise from \$916,331 for the existing herd to \$1,351,000 for the 600-cow herd (line 2). After an allowance for depreciation (line 4), net farm income is projected to increase from \$120,669 for the 400-cow herd to \$204,649 for the 600-cow operation (line 5). Net farm income in this analysis should be interpreted as the return to the three families' labor, management, and farm net worth. No expense has been attributed to these resources at this point in the analysis; thus, net farm income is the residual return available for their compensation.

Although expansion is projected to increase net farm income by \$83,980, this is not a clear indication of acceptable compensation for the additional operator(s) and family labor, management, capital, and risk associated with the project. It is assumed the Steins want to take \$70,000 out of the business to support two families with the 400-cow herd and \$100,000 to support three families if the herd is expanded to 600 cows. If it is further assumed that these family draws are reasonable approximations of the cost of operator's labor and management, these amounts can be subtracted from net farm income, plus interest paid on debt (line 6), to obtain the returns to total (debt and net worth) assets (line 8). As indicated on line 10, these returns amount to an 8.6% and 12.4% rate of return on total assets for the 400- and 600-cow herds, respectively. Further, the rate of return on farm net worth (\$702,604) is projected to increase from 7.2% (400 cows) to 14.9% (600 cows, line 13). These improvements in capital returns strongly suggest a profitable investment.

However, the most critical profitability test is the rate of return on the added investment and a comparison of that rate with the interest rate reflecting the cost of the investment. As noted on line 16, the \$508,000 expansion investment is projected to earn an annual return of 20.5%. The interest rate on the \$508,000 loan is 9%, thus the investment is quite profitable.

The second phase of the financial analysis compares cash inflows with cash outflows. As noted before, net cash available obtained by subtracting cash operating expenses from gross cash receipts, is projected to increase from \$165,669 to \$271,649 (lines 3 and 19). This available cash must be used for family living (line 20), federal and state income taxes and social security taxes (line 21), payments on term (over one year) debt (25), and replacement of depreciable capital assets (line 27). The latter item does not include the replacement of the 200 cows purchased to expand the herd, since the Stein's long-run policy is to replace cows with retained (contract-raised) heifers. After meeting all cash needs a cash surplus of \$10,845 is projected for the pre-expansion business and \$6,990 after-expansion (line 30). Under the adopted assumptions, the expansion proposal barely cash flows and is likely to cause some deterioration in the farm's cash flow position.

Solvency (or the ability of the business to assume risk) is addressed in the third segment of the analysis. Since the entire \$508,000 investment is debt financed, the debt-to-asset percentage jumps from 35.4 to 56.0 (line 34), and the net worth is unchanged (line 33). Both of these solvency measures are projected at the beginning of the expansion program. Moreover, a subsequent larger annual increase in net worth is projected to occur with expansion (\$46,564) then with the smaller herd (\$20,308, line 35). These increases in net worth result from net farm income exceeding taxes (income and social security) and family living outlays.

Another risk dimension, not shown in Table 1, is the vulnerability of the proposed expansion investment to changing milk prices, feed costs, cow productivity, etc. The impact of changing milk prices and cow productivity on the rate of return on the \$508,000 expansion investment and on the expanded farm cash flow position is reported in Table 2. A drop in milk prices from the assumed base price of \$12 to \$11 per cwt., assuming 21,000 pounds of milk production, results in an investment that is still profitable (i.e., 11.9% return exceeds the 9% cost), but has a substantial cash flow deficit of \$68,831 per year.

Also, if milk production is 20,000 pounds instead of 21,000 pounds and the milk price remains at \$12 per cwt., the investment is profitable (15.3% return exceeds 9%) and has a \$30,112 annual cash flow deficit. These situations illustrate that profitability and cash flow are not the same thing. For example, principal payments on term debt affect cash flow, but are not considered in computing profitability. Depreciation affects profitability on a dollar-

for-dollar basis, but impacts cash flow only through tax savings. A comprehensive analysis will address both profitability and cash flow performance.

Another method of understanding the risks associated with the expansion investment is to compute break-even values for selected key, yet uncertain, variables. For example, the rate of return on the added expansion investment equals the cost of the capital used to finance the investment (9%) when the milk price is \$10.63. Thus, the investment is profitable if milk prices exceed that amount and unprofitable if prices fall below \$10.63. A breakeven cash flow for the expanded 600-cow dairy is realized with a milk price of \$11.88; thus, cash flow problems can be anticipated if milk prices fall below \$11.88.

Relative risks for the current and expanded business can also be identified by computing the change in net farm income and cash flow associated with a 10% change in gross receipts. Of course, gross receipts could vary due to changes in commodity price and/or cow productivity. A 10% change in gross receipts results in a change in net farm income of \$108,200 for the 400-cow herd and \$162,310 for the 600-cow herd. The variation in net cash flow is \$77,840 and \$104,498 for the current and expanded herds, respectively. These results underline the greater risks associated with the more heavily debt financed 600-cow herd.

In summary, the long-range analysis indicates the proposed expansion is very profitable under the base assumptions. Although the investment does cash flow, it is highly vulnerable to small reverses in milk prices, cow productivity, and other adversities. Due to the strong profitability of the investment, the Steins should be in a good position to negotiate debt repayment terms (e.g., interest rate and loan repayment period) that are consistent with the investment's cash flow. Clearly, the expanded business is more financially vulnerable than the current operation. Thus, the Steins will want to weigh very closely the trade-off between the increased profit and the added risk associated with the expansion investment. If the Steins and their lender are willing to accept the added risks, the proposal appears to make it financially feasible for the second son and his family to join the dairy partnership, a goal shared by the Stein families. It is likely the Steins will want to pursue further the expansion proposal.

Transitional Planning

Planning should now focus on the transitional period. The Steins are contemplating a major expansion and adjustment problems can be expected. Thus, the Steins should be encouraged to budget cash inflows and outflows over the first one to two years of the expansion to determine if transitional problems will result in capital needs not identified by the long-range analysis. An estimate of cash deficits should permit a more effective job of planning for cash needs, thus reducing the risk of experiencing loan payback difficulties, family living shortfalls, and perhaps failure to reach long-term goals.

Expansion Control

Assuming the funds needed to implement the expansion are forthcoming on terms consistent with the financial analysis and the investment is made, the Steins should use whatever management tools are available for controlling the expansion program. The challenge now becomes one of assuring that the projected favorable outcome is realized. Keeping good records, particularly cash flow records, and comparing actual performance with projected performance should be a helpful control tool. Also, the Steins should give close consideration to other options they may have for reducing risks, especially during the transition period. These may include an intensified herd health program, forward contracted feed purchases, forage testing, maintaining a higher level of financial liquidity, etc.

Summary

Some dairy farmers and their consultants may be reluctant to do the comprehensive planning and analysis suggested by the above discussion. Foremost among the reasons for this reluctance is the associated time, mental anguish, and frustration of predicting the future. However, it should be noted that as long as the payoff from planning and analysis exceeds the costs of the time and effort involved, it is a good investment. Given the heavily capitalized, highly competitive, low margin, and high risk nature of today's milk production industry, benefits from comprehensive expansion planning are likely to be considerable. Clearly, expansion and/or facility adjustment decisions based on thoughtful projections of profitability, cash flow, and risk will be superior to those where hunches, hope, and availability of funds are the primary criteria.

* Computer programs designed for the financial analysis of investments in agricultural capital assets have also been developed by faculty at Washington State University. A free brochure describing the programs and ordering procedures can be obtained from Gayle Willett, Department of Agricultural Economics, Washington State University, Pullman, WA 99164-6210.

Table 1: Financial analysis of the added investment required for herd expansion, H. & O. Stein.¹

	400 cows	600 cows
Plan Description:		
number of cows	400	600
change in investment	0	\$508,000
change in debt	0	\$508,000
Projected Profitability:		
1. gross cash receipts	\$1,082,000	\$1,623,000
2. cash operating expenses	916,331	1,351,000
3. net cash farm income (1-2)	165,669	271,649
4. depreciation	45,000	67,000
5. net farm income (3-4)	120,669	204,649
6. interest paid on debt	42,431	92,651
7. value of operator labor & mgmt.	70,000	100,000
8. return to total farm assets (5+6+7)	93,100	197,300
9. total farm assets	1,087,800	1,595,800
10. rate of return on assets (8/9)	8.6%	12.4%
11. total net worth (start of plan)	702,604	702,604
12. return to farm net worth (5-7)	50,669	104,649
13. rate of return to net worth (12/11)	7.2%	14.9%
14. returns to added investment (line 8) —	—	104,200
15. added capital investment —	—	508,000
16. rate of return on added investment —	—	20.5%

Projected Cash Flow:

17. net cash farm income		165,669	271,649
18. net non-farm cash income	—	—	
19. net cash available		165,669	271,649
20. family living		70,000	100,000
21. income & social security taxes		30,361	58,085
22. cash avail. for principal payments		65,308	113,564
23. farm interest paid		42,431	92,651
24. cash avail. for prin. & int. (22+23)	107,739	206,215	
25. total scheduled principal & interest	93,790	199,225	
26. cash avail. after loan payments		13,949	6,990
27. annual capital replacement		50,000	75,000
28. principal paid on non-R.E. term debt	46,895	102,110	
29. cash req. for capital replacement		3,105	—
30. cash surplus (deficit)		10,845	6,990

Projected Solvency (beginning of expansion):

31. total farm assets		1,087,800	1,595,800
32. total farm debt		385,196	893,196
33. farm net worth		702,604	702,604
34. debt:asset ratio	35.4%	56.0%	
35. annual change in net worth (5-20-21)		20,308	46,564

1: Adapted from FINLRB, a computer program designed for whole-farm financial long-range budgeting, Richard O. Hawkins, et al., center for Farm Financial Management, University of Minnesota, St. Paul.

Table 2: Rate of return (ROR) on the added investment and net cash flow (NCF) for herd expansion, selected milk prices, and milk production per cow, H. & O. Stein.

lbs. milk /cow	milk price (\$/cwt.)		\$11.00		\$12.00		\$13.00	
	%ROR	NCF(\$)	%ROR	NCF(\$)	%ROR	NCF(\$)	%ROR	NCF(\$)
20K	3	-246,925	7.8	-126,925	15.3	-30,112	22.8	30,366
21K	4.1	-186,925	11.9	-68,831	20.5	6,990	27.6	75,324
22K	7.8	-126,925	16.0	-22,718	24.3	43,496	32.5	120,252

ROR refers to the rate of return on the \$508,000 investment assumed to expand the herd from 400 cows to 600 cows. The investment is profitable if the ROR exceeds the 9% cows of the capital. NCF indicates the annual net cash flow for the expanded 600-cow business.

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**Alternatives To
Antibiotic Therapy
Of Clinical Mastitis**

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Alternatives To Antibiotic Therapy Of Clinical Mastitis

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Mastitis is the most common cause of antibiotic use in adult dairy cows. In surveys of well-managed herds with somatic cell counts (SCC) under 150,000 and virtually no mastitis due to coagulase-positive *Staphylococcus aureus* (Staph.) or *Streptococcus agalactiae* (Strep. ag.), 35-55% of lactations had one or more incidents of clinical mastitis (2,4,7,8,9). In such herds, 15-40% of the clinical cases had no bacteria isolated from the milk, 21-43% had coliforms, and 9-32% had environmental streptococci (1,2,4,7). This contrasts with high SCC herds with a significant prevalence of Staph. and Strep. ag., where most of the clinical mastitis is caused by those organisms (4). As more herds respond to quality incentives and stricter SCC standards by controlling the contagious pathogens, we can expect the relative importance of the environmental pathogens to continue to increase.

Antibiotic treatment of clinical mastitis incurs the cost of the drugs used, the discarded milk, and the loss of the option to cull the cow until after the withdrawal time has elapsed if treatment fails. It also incurs the risk of contaminating the bulk tank with antibiotics, and all of the expensive regulatory consequences of violative antibiotic residues under the revised Pasteurized Milk Ordinance, including a significant loss of revenue from milk. Those who design treatment protocols should be sure that the benefit of antibiotic treatment outweighs these very real economic costs.

Some dairymen and veterinarians have already decided that the risks of antibiotic use in most clinical mastitis cases exceed the benefits and have stopped treating clinical mastitis cows with antibiotics in herds with a low prevalence of the contagious organisms. They emphasize protocols of frequent milkout aided by oxytocin injections and anti-inflammatory drugs, along with heightened attention to management of housing, bedding, and premilking hygiene to prevent infection with environmental pathogens. While the anecdotal reports about such programs are favorable, there is no published data about the rate of chronic or recurring infections in such herds compared to herds using antibiotics, nor on the effects of these infections on bulk tank SCC or subsequent milk yield.

There is no published evidence that the benefits of antibiotic treatment of mild clinical mastitis outweigh the risks and costs. There are no published studies on the antibiotic treatment of mild clinical mastitis (mastitis in which the cow does not become systemically ill) under field conditions that include untreated controls. Chamings (3) reported an 87% clinical cure rate in cows that were not treated with antibiotics for mild clinical mastitis caused by Staph. and *Streptococcus uberis*. The bacteriological cure rate for both organisms was 19-20%. This study did not have a positive control group for comparison. This type of mastitis is treated on most dairies with mastitis tubes, possibly in conjunction with extra-label parenteral antibiotics or anti-inflammatory drugs. All of the approved intramammary mastitis preparations on the market in the United States as of June, 1992 were tested against subclinical infections with gram-positive organisms.

Only one has a label claim for mastitis caused by *Escherichia coli*, which is the most frequently isolated udder pathogen in many outbreaks of clinical mastitis in herds with low SCC.

The pharmacology of mastitis therapy has recently been reviewed (6,13,14). Reasons why antibiotic therapy might fail are summarized in Table 1. The underlying assumption of research on mastitis to date has been that the primary aim of therapy is to kill bacteria, and that the normal state of milk in the udder is sterility. Yet subclinical infections with environmental and contagious pathogens probably exist in every herd (4). Clinical mastitis may be due to the flareup of subclinical infection in a stressed cow. In the short run, the economically important clinical outcome in the treatment of clinical mastitis is not the absence of bacteria, but rather the return of milk and udder to their normal state, so that the cow's milk can once again be sold.

Only one common pathogen, *Streptococcus agalactiae*, is highly sensitive to and easily cured by approved intramammary antibiotics used according to the label. In most herds with low SCC the prevalence of *Strep. ag.* is low or zero. Many such herds have no *Strep. ag.* isolated from bulk tank samples or clinical cows for years. In herds with *Strep. ag.* infected cows, use of intramammary antibiotics is easily justified on medical, if not economic grounds because it stops the shedding of bacteria by the cow with clinical mastitis and because *Strep. ag.* is very sensitive to all of the antibiotic tubes on the market. Treatment of clinical mastitis in lactating cows is not effective, however, in reducing prevalence in the herd unless it is part of a total control program (11). Only an integrated program of teat dipping, milking machine maintenance, milking hygiene, and dry cow treatment can bring about a long-term reduction in prevalence.

While all mastitis tubes carry a label claim for *Staph.*, the cure rate is so low that dairymen are best advised to consider it negligible (10,11,12). The cure rate in *Staph.* cows is low because the organism forms microabscesses in the udder tissue outside the ducts, where intramammary drugs can not reach it. It also can survive inside white blood cells, makes L-forms, and can acquire resistance to commonly used antibiotics (10). The best hope for successful antibiotic treatment of *Staph.*-infected cows is in young cows with recent infections. Parenteral treatment may increase the chance of a cure (10). In herds with a high prevalence of *Staph.* infections, the emphasis should be on teat dipping, culling, milking machine maintenance, milking hygiene, and segregation of infected cows to gradually reduce the prevalence of the infection. Antibiotic treatment may reduce shedding of *Staph.* by clinical mastitis cows and thus help reduce the spread, but it will not reduce overall prevalence in the herd significantly (11).

In herds with low SCC and low prevalence of contagious pathogens, clinical experience and published surveys (1,2,4,7) show that about 15-40% of pretreatment milk samples from cows with clinical mastitis are negative for bacterial growth on blood agar. We presume that these samples containing too few organisms for a positive culture result reflect the ability of the cow's immune system to rid the affected quarter of pathogens. Antibiotic treatment of these cows is difficult to justify; the problem is that we can not know which cows they are until after treatment has to be initiated. The aim of treatment should be to return the quarter and the milk to normal, not to prevent the spread of infection. Anti-inflammatory drugs or immune modulators would seem indicated, rather than antibiotics.

A fairly large group of so-called "minor" pathogens — minor in prevalence in the industry, not to the infected cow or her owner — are refractory to all antibiotic treatment. This group includes the genera *Mycoplasma*, *Pseudomonas*, *Pasteurella*, *Serratia*, *Prototheca*, *Mycobacterium*, *Nocardia*, *Bacillus*, the yeasts and fungi, and *Actinomyces pyogenes*.

In surveys of clinical mastitis in herds with low SCCs, coliform organisms account for about one-third of isolates from clinical cows. Coliform organisms can cause mastitis of severity rang-

ing from subclinical to peracute. Erskine (5,6) has shown that clinical signs appear in experimental coliform mastitis after bacterial numbers in milk have peaked, and that treatment of these cows with intramammary gentamicin did not affect clinical outcome. Toxic mastitis can be reproduced by infusing endotoxin without living organisms into the udder; most of the clinical signs of coliform mastitis are thought to be due to the effects of endotoxin (5). Treatment should therefore aim primarily at removing endotoxin from the udder with frequent and complete milkout and at counteracting the effects of endotoxin with appropriate antiinflammatory and supportive treatments. The most important part of a treatment protocol for coliform cows is to milk the quarter out completely and often, possibly with the help of oxytocin injections. Unfortunately, treatment must begin before the organisms involved can be identified, and the appearance of the abnormal secretions alone is not a reliable basis for an etiologic diagnosis, except perhaps in the most severe cases.

The environmental streptococci and the coliforms account for the majority of environmental clinical mastitis cases where a diagnosis is obtained. Philpot (11) cited a cure rate for clinical mastitis caused by environmental streptococci of 36%. Erskine (6) states that acceptable cure rates (>75%) are attainable with a combination of intramammary antibiotics and intramuscular procaine penicillin G. Tyler (13) states that response of clinical *Streptococcus uberis* infections to antibiotic therapy during lactation is poor, although a combination of parenteral and intramammary erythromycin appears to be the most efficacious treatment. More research is needed on these organisms, particularly on any long-range benefit from antibiotic treatment in eliminating chronic infections during lactation.

The challenges in treating clinical mastitis in a herd with low SCC are the impossibility of establishing an etiologic diagnosis at the time of first treatment, the fact that about a third of cows being treated have already cleared the infection, and the fact that in the case of the coliforms at least, the primary aim of treatment has to be to counteract the effects of endotoxin rather than reducing bacterial numbers. This must be accomplished without incurring undue risk of antibiotic contamination of milk, in the absence of clear experimental evidence from controlled trials that antibiotic treatment of mastitis is efficacious or cost-effective. Clearly more research is needed.

A controlled study of intramammary treatment for mild clinical mastitis caused by environmental bacteria was recently completed at the Veterinary Medicine Teaching and Research Center of the University of California, Davis. We compared the efficacy of cephalixin and amoxicillin mastitis tubes to that of oxytocin alone in the treatment of mild clinical environmental mastitis. Both tubes were used according to label instructions. Oxytocin cows received 50 units of oxytocin intramuscularly just before milking. No other treatments were used on cows in the study. No contagious pathogens were isolated from any of the clinical cases. Cows treated in the study had mild mastitis, that is, abnormal milk with or without udder swelling, and no signs of systemic illness, and were randomly assigned to one of the three treatments. Cows that did not improve or got worse during the observation period were called treatment failures and withdrawn from the trial. A clinical cure was the return of the affected quarter and milk to normal at the eighth milking after initial diagnosis and treatment. A bacteriologic cure was the failure to isolate the primary pathogen present at the first milking at the eighth milking and at 20 days after initial treatment. Results are shown in tables 2, 3 and 4. Herds 1 and 3 were located in San Joaquin County and Herd 2 in Kings County.

In the past, the standard recommendation was to treat all cows with clinical mastitis with antibiotic tubes used according to the label. In herds with low SCC where all clinical mastitis is

caused by environmental bacteria, we can design better treatment protocols that minimize antibiotic use, reduce the risk of residues, and still allow flexibility to beef affected cows if treatment does not work. A responsible treatment protocol requires that permanent records of clinical mastitis be kept so that a cow's past history can be consulted before treatment is initiated.

Clinical mastitis should be classified before treatment as mild or severe. Mild mastitis would be characterized by abnormal milk and slight udder swelling, while severe mastitis would include abnormal milk, severe swelling, the risk of losing the quarter, and systemic illness (fever, off feed, diarrhea).

Before a protocol is put in place, the veterinarian should collect and analyze the results of sampling of clinical mastitis cows to determine the pathogens generally involved on the particular farm in different seasons. On a farm with a significant incidence of clinical mastitis caused by *Strep. ag.*, for example, antibiotic tubes should probably be used on most clinical cases, while on a farm where a third of the clinical samples show no growth and another third yield *E. coli* antibiotic use is hard to justify.

Dairy personnel should be trained to look at the cow's record before beginning a course of lactating cow treatment. The people making the treatment decisions, usually milkers or herdsmen, need to be trained and trusted to make these decisions properly. The veterinarian and the owner should develop a treatment protocol based on the known past history of pathogens in the herd, age of the cow, reproductive status, milk yield, relative value in the herd, past mastitis history, other unsoundnesses (locomotor problems, poor udder conformation, etc.), and the severity of clinical signs. For example, a cow that is below the herd average, open, and late in lactation will most likely be culled eventually anyway and might as well be culled now that she has mastitis. An average first-lactation cow that is late in gestation should be dried off early, since dry cow preparations are stronger, stay in the udder longer, are more likely to clear up the infection than lactating cow tubes, and present less risk of contaminating the bulk tank with antibiotics. Cows with persistent or recurring infections despite past treatment are unlikely to respond to a repetition of the same treatment protocol. The risky approach on these cows is to turn to extralabel use of parenteral antibiotics, with all of the risk of illegal residues it entails. A safer approach is to evaluate the cow's record and the severity of the infection and decide either to cull the cow, dry her off, treat her, or to let her recover on her own. A young, high-yielding cow in early lactation with mild mastitis might be treated aggressively, with an emphasis on frequent and complete milkout.

Treatment protocols should be modified to fit the culling philosophy and goals of each dairyman. A dairyman who is trying to build up herd numbers, for example, may be more inclined to dry off a clinical mastitis cow than one whose facility is overcrowded and is looking for room for a new heifer. A dairyman may be unwilling to cull his purebred cows under any circumstances.

On large dairies an aid in the management of clinical mastitis is to have a designated mastitis string, which is milked last, just before the hospital or antibiotic string. The mastitis string is milked into the bulk tank. It contains all cows that have had clinical mastitis during the current lactation, chronic high SCC cows, and cows known to be infected with *Staph.* that the owner does not want to cull. On some dairies it might include slow-milking cows and cows with poor udder shape that require extra attention at milking time. On others the slow cows are in a separate group. Cows in the mastitis string are generally not to be treated with antibiotics when they get clinical mastitis again. They are either culled, or milked out with the aid of oxytocin injections until their milk is normal. Since abnormal milk may not be put into the bulk tank, these cows with clinical mastitis must either be milked into a separate bucket or put in the hospital

string until their milk is normal. Cows may leave the mastitis pen only to be dried-off or culled, or if their individual SCC remains below 200,000 for three consecutive test days and they are not known to be infected with a contagious pathogen.

Treatment of clinical mastitis is the most common use of antibiotics on dairy farms and the most common cause of illegal antibiotic residues. On well-managed dairy farms most mastitis is caused by the environmental pathogens. There is no data from well-controlled studies demonstrating the efficacy of antibiotic treatment of clinical mastitis caused by the environmental pathogens, nor on any benefit of antibiotic treatment on chronic or persistent infections. However even in the absence of data the veterinarian can be very helpful in developing treatment protocols that greatly reduce the use of antibiotics and decrease the risk of violative residues.

Table 1: Reasons For Failure Of Antibiotic Therapy Of Clinical Mastitis.

- A. Drug can not reach all sites of infection.
 1. Microabscess formation (Staph)
 2. Blockage of ducts with clots of denatured milk.
 3. Poor distribution of drug in udder, due to swelling, edema, or intrinsic properties of drug.
 4. Abscessation
 5. Fibrosis
 6. Intracellular bacteria (Staph.)

- B. Bacteria already killed by cow's immune system before therapy begins.

- C. Inadequate concentration of drug to effect killing.
 1. Poor distribution of drug in udder.
 2. Absorption of drug from milk into systemic circulation.
 3. Failure of drug to be absorbed by affected tissues
 4. Drug milked out at subsequent milking.
 5. Failure of parenteral drug to cross blood-milk barrier.
 6. Failure of client or veterinarian to repeat treatments in time to maintain MIC in tissue long enough to effect killing.

- D. Bacteria refractory to killing by drug.
 1. Bacteria not in rapid growth phase required for drug to act.
 2. Organism is resistant to usable antibiotics (e.g., Pseudomonas, Mycoplasma, yeasts, etc.)
 3. Drug with gram-positive spectrum used on gram-negative infection.
 4. Acquired resistance by organism.
 5. Emergence of L-forms, "naked" acapsular forms that resist beta-lactam antibiotics.

- E. Reinfection of affected quarter.

Table 2: Pretreatment bacterial isolates of 3 treatment groups in randomized field trials of therapies for mild clinical mastitis, California, 1991-1992 (%)^{*}.

Variable	Treatment			P value
	Oxytocin	Amoxi-mast	Cefa-lak	
Coliform	33.3	41.9	37.3	0.93
Streptococcus sp.	26.7	23.0	26.7	

Other	15.2	10.8	13.3
Negative	24.8	24.3	22.7
Number of cows	105	74	75

(* : Of the 94 coliforms, 81 (86%) were E.coli. Of the 65 Streptococcus sp., 27 (42%) were S.uberis, 19 (29%) were S.dysgalactiae, and 14 (22%) were S.viridans. Of the 34 "Other" bacteria, 14 (41%) were Staphylococcus sp. (primarily S.hyicus), 9 (26%) were mixed infections, 3 (9%) were Bacillus sp., and 3 (9%) were Corynebacterium sp.

Table 3: Bacterial and clinical cure (%) by treatment group and herd in randomized field trial of therapies for mild clinical mastitis, California, 1991-1992.

Herd	Treatment			P value
	Oxytocin	Amoxi-mast	Cefa-lak	
Bacterial cure %*				
Herd 1 (n=64)	10/26 (38.5)	9/20 (45.0)	11/18 (61.1)	0.33
Herd 2 (n=31)	6/10 (60.0)	6/10 (60.0)	6/11 (54.5)	0.96
Herd 3 (n=43)	12/21 (57.1)	3/11 (27.3)	5/11 (45.5)	0.27
Total (n=138)	28/57 (49.1)	18/41 (43.9)	2/40 (55.0)	0.61
Clinical cure %				
Herd 1 (n=82)	23/33 (69.7)	20/24 (83.3)	17/25 (68.0)	0.41
Herd 2 (n=86)	19/36 (52.8)	12/25 (48.0)	16/25 (64.0)	0.50
Herd 3 (n=86)	28/36 (77.8)	18/25 (72.0)	7/25 (68.0)	0.69
Total (n=254)	70/105 (66.7)	50/74 (67.6)	50/75 (66.7)	0.99

(*: Of 254 cases, 61 were culture negative prior to first treatment, 43 were given additional treatment prior to 9th milking, 2 were treated between 9th milking and 21 days, 2 were dried prior to 21 days, 4 were culled before 9th milking, and 4 were culled before 21-day sample.)

Table 4: Bacterial and clinical cure (%) by treatment group and bacterium isolated at pretreatment sampling in randomized field trial of therapies for mild clinical mastitis, California, 1991-1992.

Herd	Treatment			P value
	Oxytocin	Amoxi-mast	Cefa-lak	
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Coliforms (n=63)	15/26 (57.7)	8/21 (38.1)	8/16 (50.0)	0.41
Strep. sp. (n=49)	10/21 (47.6)	6/13 (46.2)	11/15 (73.3)	0.23
Other bacteria (n=26)	3/10 (30.0)	4/7 (57.1)	3/9 (33.3)	0.48
Pos. culture (n=138)	28/57 (49.1)	18/41 (43.9)	22/40 (55.0)	0.61
Clinical cure %				
Coliforms (n=94)	22/35 (62.9)	21/31 (67.7)	14/28 (50.0)	0.36
Strep. sp. (n=65)	17/28 (60.7)	9/17 (52.9)	14/20 (70.0)	0.56
Other bacteria (n=34)	7/16 (43.7)	7/8 (87.5)	9/10 (90.0)	0.02
No bac. isol. (n=61)	24/26 (92.3)	13/18 (72.2)	13/17 (76.5)	0.18
Total (n=254)	70/105 (66.7)	50/74 (67.6)	50/75 (67.7)	0.99

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Other bacteria (n=26)	3/10 (30.0)	4/7 (57.1)	3/9 (33.3)	0.48
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Body Condition,
Energy And Health
In High-Producing
Dairy Cows

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1993
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Body Condition, Energy And Health In High-Producing Dairy Cows

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Adipose tissue, or body fat, is an animal's means of storing energy during times of nutritional excess for later use when food energy is insufficient for the animal's needs. This is as true for dairy cows as for other animals. In the past, the balance of fat deposition versus fat mobilization was used in dairy management schemes as a simple means of improving production with the concept that cows could be fed to gain weight at one time so they could "milk off their backs" at a later time when the production needs exceeded feed energy supply. During the 1970s, research and clinical evidence demonstrated substantial health problems associated with energy over-feeding that resulted in fat cows. A considerable amount of research has been conducted since then expanding our knowledge of dairy cow nutritional physiology and to the interactions between health productivity and energy supply and demand.

Body condition scoring (BCS) systems have been developed and validated as an accurate means of evaluating dairy cow fat and energy reserves. These systems have been promoted as useful in management of high-producing cows, and many dairymen and dairy consultants have begun to incorporate body condition scoring into their monitoring schemes. For many reasons, there is no single universal accepted estimate of optimal BCS. Well conducted research focuses on one or several very specific questions, so different trials conducted under different circumstances often show results that seem to conflict. Some research findings seem to contradict knowledge or convictions people have formulated by personal experience. As a result, the use of body condition scoring may seem limited or confusing, or simply opinion-based.

The purpose of this presentation is to discuss some of the interactions between energy utilization, productivity and health of high-producing dairy cows and how they relate to body condition score. An appreciation of these factors should allow the dairy producer to use body condition scoring wisely and to tailor it to individual needs.

Fat metabolism

As ruminants, dairy cattle ferment feedstuffs in their large forestomach. This single fact directly impacts virtually all aspects of their energy metabolism. As part of the fermentative process, rumen bacteria break down the overwhelming majority of carbohydrates that enter the rumen. These carbohydrates include the simple sugars, cellulose and starches that are the major energy and structural components of plants. The end products of this fermentation are small fats known as volatile fatty acids (VFA). These VFAs are absorbed through the gut wall and utilized as the primary energy source for the ruminant animal. One result is that almost no glucose is available to the ruminant by absorption from the gut. Instead, ruminant metabolism relies almost exclusively on fat in one form or another.

The VFAs derived from digestion can be directly used by the animal or converted to longer chain fats for storage if they are produced in excess of the cow's immediate energy needs. Besides the cow's needs for basic body maintenance, the largest single energy demand in the

high-producing lactating dairy cow is for milk production. While many tissues can derive their energy directly from fat, the mammary gland has an absolute requirement for glucose in order to produce milk. Since the cow does not absorb glucose from the digestive tract, almost all glucose for milk production must be manufactured in the liver. The VFAs are directly utilized by the liver for this purpose. For a dairy cow producing between 90 and 120 pounds of milk a day, this amounts to a complete turnover of the glucose in her blood approximately every four to six minutes, a truly remarkable metabolic feat. Because of this direct link between VFA production, conversion to glucose and utilization for milk production, it may not be surprising that the feeding factor with the highest direct correlation to milk production is the total dry matter intake (DMI). The VFAs can also be used to produce milkfat.

If the VFAs are not directly used for tissue metabolism or milk production, they can be combined in the liver into longer-chain fats that are transported to the adipose tissue for storage. When the supply of VFAs is too low to support the animal's needs, this fat is then mobilized and transported via the blood back again to the liver for conversion to a more usable form. The fat can be used for energy, converted to glucose, or used to produce milkfat. The various pathways through which fat is utilized are influenced and regulated by a complex of enzymes and hormones. Not all metabolic pathways can be optimally or maximally used at all times.

Fat versus health

Over the last 20 years some strong associations have been seen between body condition or fat mobilization and poor health in dairy cows. Some of the health problems are profound life-threatening problems, while others are more insidious and result in poor performance but little overt disease. Thus some problems directly call attention to the problem of over-conditioning, while others require a more careful monitoring system to detect.

The most dramatic disease of over-conditioned dairy cows is a problem that has been known as "fat cow syndrome." This problem occurs in the immediate periparturient period. It involves a severe metabolic derangement and multiple organ system failure. The typical affected cow will show signs of milk fever, usually with recumbency. It is difficult to ever get these cows to rise again and prolonged recumbency leads to severe muscle damage. Also seen in most cases are retained fetal membranes and the cow appears to have impaired ability to control infectious disease. Instead of showing localized uterine infection, the cow rapidly develops signs of septicemia with widespread infection, to which she does not respond appropriately. Mastitis is also frequently seen in addition to the uterine disease. Affected cows are usually severely ketotic and anorectic. The prognosis for affected animals is very poor. Fortunately, this condition is usually seen in individual animals but when such a case occurs, may reflect poor overall nutritional management with over-feeding of the late gestation cows in the herd.

More insidious is the fatty liver syndrome in dairy cows. Cows with this problem are usually not obese at the time they show signs of disease. Instead they are usually cows that have lost excessive amounts of body condition since freshening. Signs appear three to eight weeks post partum, when cows have been in chronic negative energy balance for a period of time. The signs include decreased milk production and chronic ketosis that does not respond appropriately to therapy. With chronic negative energy balance, affected animals mobilize excessive amounts of fat from their peripheral fat stores. As described above, this fat circulates to the liver where it should be used for a variety of different metabolic end purposes. If the fat mobilization is excessive, however, not all of the fat is appropriately channeled through the different metabolic pathways. Some of the fat is stored in the liver, leading to the change for

which the disease was named. Some of the fat is partially metabolized but inadequate functioning of the metabolic pathway leads to accumulation of partially oxidized fats known as ketones. This excessive ketone body production, known as ketosis, can produce further anorexia and exacerbate the problem. Ketosis can develop whenever lactating cows go off feed, so this problem is commonly seen in association with other diseases. In fatty liver disease, the primary problem is the metabolic imbalance of inappropriate utilization of the excessively mobilized body fat stores. If affected animals are identified promptly, they can respond to aggressive treatment very favorably. On the other hand, if the problem continues over a prolonged period, the cow will cease to be productive and may develop severe enough problems that she dies. The existence of fatty liver disease cows in a herd suggests a problem of insufficient energy feeding to early and peak lactation cows.

The most insidious disease problems associated with fat metabolism in dairy cows are those that do not show overt signs of disease. Numerous studies have shown that cows losing excessive amounts of body condition in early lactation develop high amounts of fat infiltration in the liver. Not all of these cows will show fatty liver disease with its associated severe ketosis and decreased milk production. In fact, many of the highest-producing cows in the herd will typically develop severely increased liver fat but still not show clinical ketosis. It appears that liver function per se is not adversely affected except in a minority of these weight-losing cattle. They are, however, still experiencing abnormal fat metabolism, which can be demonstrated with a variety of different analytical methods in research settings. The exact mechanisms by which this abnormal fat metabolism affects other aspects of animal health has not been clearly defined. What is clear is that these animals show a higher rate of reproductive inefficiencies, prolonged days to conception and prolonged calving intervals, and increased incidences of metabolic and infectious diseases.

Body condition

Research data as well as personal opinions vary concerning the optimal body condition score for cows at freshening. Many recommendations are complicated because of variations in feeding practices from farm to farm. In general, there is good agreement that excessive body condition is detrimental to performance. Where recommendations vary is on whether cows should be on the thinner or the heavier side of a mid range body condition score. There is substantial agreement of research information on the interaction between body condition score and a variety of other parameters important to dairy cow performance. An understanding of some of these will provide a perspective on decisions concerning BCS in cows in individual herds.

As mentioned earlier, total dry matter intake has a very strong correlation with total milk production. In the last week prepartum, most cows decrease their dry matter intake both before and after calving. Several studies have shown that fatter cows decrease DMI more substantially than thinner cows. These trials have also shown that cows with lower BCS, because they tend to consume more dry matter, will also have a decreased time of negative energy balance post partum and will produce the same or more milk than fat cows while mobilizing less fat from their peripheral tissues. As a result, leaner cows will tend to lose less weight postpartum and therefore will tend to suffer fewer disease episodes and be more efficient at breeding back.

Much of the positive effect of calving cows in leaner body condition seems to result directly from the increased dry matter intake these cows are able to sustain. A recent study showed that by force-feeding cows for increased dry matter intake, the high DMI cows developed

less liver fat postpartum and showed increased production. Relating to the discussion above about dairy cow fat metabolism, it is also more biologically efficient for cows to produce milk directly from feed energy than by converting the feed energy to fat and then fat to milk. The biological efficiency of converting feed to milk energy or to body fat is approximately the same at about 60%, while conversion of fat energy to milk energy is a higher efficiency, at about 80%. The two steps involved in converting feed first to fat and then to milk energy decreases the efficiency to around 50%. On the same note, this effect is even more severe if the body fat stores are laid down during the dry period. Cows are more efficient at gaining weight while in the late lactation period and, if the fat is deposited during the dry period, the biological efficiency is decreased to somewhere between 30 and 45%. Therefore, aside from any considerations of the health effects of overconditioning cows, it is simply more cost-effective to attain as much milk production as possible directly from feed intake.

With these thoughts in mind, the ideal situation would be to maintain a thin cow who can consume enough feed to maintain optimal milk production while neither gaining nor losing weight. Unfortunately, this goal is as yet unattainable. It is clear, however, that to obtain optimum milk production and cow health, both BCS and nutrition should be critically monitored to obtain maximum dry matter intake postpartum and avoid excessive condition loss during the first several months postpartum. The BCS loss is more detrimental to the cow than is excess condition itself but excess condition will in turn lead to a greater tendency toward condition loss.

A BCS monitoring program can be relatively easily implemented. Using such a system will allow cows to be grouped both for milk production and BCS. The BCS should be viewed critically to observe for changes associated with suboptimal feeding and for discrepancies between feeding recommendations and feed intake. Target goals can be established for cows in each lactation group and feeding patterns adjusted to attain that goal if large numbers of cows fall outside the target range. Individual cows falling outside the target range can be moved to other feeding groups to help correct for those problems. In a well managed system, less than 10% of the cows in a group should fall outside of the target range.

General rules of thumb that seem to be agreed upon by a wide variety of trial results suggests that the mean condition scores of the dry cows and the peak lactation cows should not vary by more than one-half BCS unit. While cows will lose some condition in the early lactation period, this should probably not exceed one condition score. Body condition should improve in the middle and late stages of lactation so cows can dry off in the condition in which it is desired that they calve. If cows do dry off overconditioned, they should be maintained at the current weight or reduced only slightly. Drastic weight loss feed regimens in the dry period are probably more detrimental than weight loss in early lactation.

Recommendations for optimum body condition score at the various lactation stages will be argued by some but my recommendations would be as follows: on a condition score system of one to five, with one being a very thin cow and five an obese cow, animals at drying off and parturition should be between 3.0 and 3.5. Condition loss should be maximal at one to two months after calving and at the pre-breeding examination, BCS should be about 2.5 or a little greater. Body condition should stabilize and then begin to improve after about 90 to 100 days in milk, so BCS at the pregnancy examination should be stable or a little bit improved. An additional BCS measurement at about 100 days before drying off should show the cow improving condition back toward the levels desired at dry off. This is a good time to adjust the feeding regimen to obtain optimal BCS at the dry period.

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Computerized
Treatment Records
For Disease Control
And Residue
Avoidance

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1993
WESTERN LARGE HERD
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Computerized Treatment Records For Disease Control And Residue Avoidance

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Dairymen and veterinarians have long recognized the value of production and breeding records. These records are maintained accurately because the information is routinely used by owners, employees and consultants for making cow and herd decisions. Computerization of these records has greatly increased their usefulness in large herds. Detailed medical records of treatments administered to cows and calves are less commonly maintained. Typically, dairy medical record systems include temporary records such as cow markings, a blackboard, daily treatment logs or a pocket notebook. Some managers also record the disease on the cow page of the herd record system. Information is often limited to disease, drug administered and first or last date treated. Doses, routes of administration, repeated treatments and withholding times are less commonly recorded. More detailed medical records are often not maintained because they are perceived as time consuming and unnecessary to dairy management.

Many owners and managers have delegated drug selection and treatment decisions to animal caretakers. Animal caretakers frequently have little supervision and may alter drugs and doses used based upon impressions of treatment responses in individual animals. These practices ignore the value of using consistent, medically correct criteria for disease diagnosis and basic principles of drug use. Because consumer groups are aware of these common animal care practices, they have pressured regulatory agencies to encourage more responsible use of drugs in livestock production. Producers, veterinarians and government agencies all recognize that responsible use of drugs in dairy animals is impossible unless the identity of treated animals is assured through careful maintenance of treatment records. Treatment records are also required by federal regulations whenever prescription or extralabel drug use occurs and when residues are investigated. Records are also a key element of the National Dairy Meat and Milk Quality Assurance Program. For each prescription and extralabel treatment given a food animal, the animal identification, treatment date, disease, drug, dose and route of administration should be recorded.

Manual medical record systems listing individual animals treated over a period of consecutive days with several drugs, each with different withholding times, or with extra-label treatments, overdoses and other deviations from standard procedures can be very difficult to use in determining proper withholding periods. Errors can easily be introduced when counting hours and days following the last treatment. Herd management software often permits entry of treatment information, but rarely provides much more than "read only" output, i.e., they do not assist the user in managing treatment and residue avoidance programs. Software that guides continuing treatments, assists in determining and observing withholding periods

and that makes record-keeping easier would also likely result in fewer errors and provide a more easily used database than paper records.

Computerized treatment records developed by the University of California Veterinary Medicine Teaching and Research Center can be used for health management in addition to fulfilling regulatory requirements. They can assist the producer in making treatment and culling decisions, calculate disease and mortality rates and assist in determining effectiveness of disease prevention programs, treatments and culling strategies. Dairymen who have recently changed or eliminated some treatment protocols because of residue avoidance concerns can easily evaluate these alternative strategies with this record system. They have also been used to document vendor invoicing errors, drug theft, diligence of animal caretakers, animal treatment costs and drug savings from revised treatment protocols.

While use of prescription and ELUD treatments is often unavoidable in dairy animals, current federal regulations require that such drug use be guided by the herd veterinarian. The residue avoidance software guides treatment personnel using veterinary designed protocols unique to each herd and updated to reflect changing herd conditions. This fulfills, in part, the requirements of a veterinarian-client-patient relationship. On-farm treatment personnel recognize common signs of illness, and choose the treatment selection stored in the computer that matches the observations. Upon selection of an appropriate presentation of signs, the computer prints instructions for treatment including drug, route and dose for that animal based upon body weight or other defined criteria (Table 1). The record system accommodates individualized treatments for animals with specific signs not preprogrammed into the software. These treatments can be selected using individual drugs according to label directions. At the end of a prescribed course of treatment the program prompts the caretaker to discontinue treatment. Animals that have not recovered can be placed on treatments programmed by the herd veterinarian for such cases, or seek veterinary assistance.

The herd veterinarian sets meat and milk withholding times in advance for each treatment regimen. The program monitors therapy actually administered to each animal, automatically updating meat and milk withholding times with each treatment (Table 2). Users can query the database about any animal or group of animals to determine their eligibility for sale or return to a milking string (Table 3).

This medical record and treatment software meets several needs. The producer has data to objectively judge the merits of various aspects of dairy health programs. The veterinarian can better advise his client. Installation of such a program fulfills the record keeping requirements of federal regulations and the Milk and Dairy Beef Quality Assurance Program. Producers and marketing organizations concerned with food safety and consumer concerns are provided a tool to document responsible management by dairymen and veterinarians. It is possible that more professionally designed treatment programs and careful documentation of treatment practices will improve animal health and welfare, consumer confidence and food safety.

Minimum system requirements to operate the software in large herds are an IBM-compatible, 286 or better processor with 640K memory and a hard disk. The software is available and supported through the National Dairy Meat and Milk Quality Assurance Program distribution agency — Agri-Education, Inc., 801 Shakespeare Avenue, Stratford, Iowa, 50249.

TABLE 1
Milky Way Dairy
AM To Do List for HUTCH Pens on Wednesday, April 22, 1992

Drug Administrations:										
Pen	Cow ID	Date	Disease	Drug	Dose	Units	Route	Mod	Cln	Tech
HUTCH	407B	04/22/92AM	PNEU	NAX	3	CC	IM	N	CV	
HUTCH	424B	04/22/92AM	PNEU	NAX	3	CC	IM	N	CV	
HUTCH	4501C	04/22/92AM	PNEU	NAX	2	CC	IM	N	TR	

Decisions:						
Pen	Cow ID	Date	Disease	Decision		Tech
HUTCH	412B	04/22/92AM	PNEU	REPEAT TREATMENT? [YES/NO]		
HUTCH	415B	04/22/92AM	PNEU	REPEAT TREATMENT? [YES/NO]		

Withdrawal Completed:			
Pen	Cow ID	Date	Tech
HUTCH	412B	04/22/92AM	
HUTCH	415B	04/22/92AM	
HUTCH	4399C	04/22/92AM	
HUTCH	4430C	04/22/92AM	

TABLE 2
Milky Way Dairy
Medical History Report (Report Date: 04/21/92)

		Withholding Dates						
Cow ID: 1408B	Weight: 300 lbs	Milk: 12/16/91PM	Meat: 12/28/91AM					
Dispose:		Remarks:						
Hospital Visits								
Admitted	Released	Loc	Dis	Date Diag.	Tx	Milk	Meat	
10/08/91	10/17/91	HOS3	LAME	10/08/91AM	1	10/16/91AM	11/07/91AM	
12/11/91	12/17/91	HOS1	PNEU	12/11/91AM	1	12/16/91PM	12/28/91AM	
Treatments Done								
Date	Dis ID	Drug	Dose	Units	Route	Tech	Mod?	Clinician
10/08/91AM	LAME	PPG	30	CC	IM	JC	Y	TR
10/09/91AM	LAME	PPG	12	CC	IM	JC	N	TR
10/10/91AM	LAME	PPG	12	CC	IM	JC	N	TR
12/11/91AM	PNEU	ALBNI	35	CC	IV	HVK	N	TR
12/12/91AM	PNEU	ALBNI	35	CC	IV	HVK	N	TR
12/13/91AM	PNEU	ALBNI	35	CC	IV	HVK	N	TR

TABLE 3
Milky Way Dairy
Current Status Report for LHOS Pen on Tuesday, April 21, 1992

Cow ID	Treatments						Withholding	
	Completed			Continuing			Milk	Meat
	Dis ID	Date	Cln	Dis ID	Date	Cln		
2734C	MASSV	04/16/92AM	AA				04/20/92AM	04/27/92AM
2771C	PNEU	04/19/92PM	TR	PNEU	04/21/92PM	STD	04/27/92PM	05/20/92PM
2795C	MASSV	04/20/92AM	TR	MASSV	04/21/92AM	STD	04/25/92PM	04/26/92AM
2801C	MASSV	04/20/92AM	AA	ALBNB	04/21/92AM	STD	05/04/92AM	05/04/92AM
2856C	DRY	04/06/92AM	TR				06/05/92AM	06/05/92AM
2882C	OB	04/19/92PM	TR				04/22/92PM	05/17/92PM

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NOTES

Heat Detection: Problems, Evaluation and Solutions

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1993
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Heat Detection: Problems, Evaluation and Solutions

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To achieve maximum genetic gains in a dairy herd, artificial insemination with top proven sires must be used on all cows and replacement heifers. The benefits of AI are clear, however AI is not without its problems, the primary one being heat detection. Errors in heat detection have a substantial effect on the length of the breeding period, conception rates, days open and calving intervals. Estimates based on DHIA information put the level of detected heats at about 50%. In other words, for every heat period detected by a dairy producer, another goes unnoticed. Barr (1) estimated that missed heats were responsible for an additional 40 days open.

Heat Detection Errors

There are basically two types of heat detection errors which can be made on a dairy farm. The first is to not observe a cow that is actually in heat. This is normally referred to as an error in heat detection efficiency (13). Efficiency errors result in an increase in the days in milk at first breeding and days open. However, there is little effect on the overall conception rate of the herd. The second error which can be made, is when a cow is inseminated that is not in heat. This is referred to as an error in accuracy (13). Accuracy errors extend the breeding period similar to efficiency errors, however, the conception rate is also affected because there is little chance that these animals, when inseminated, will conceive. Efficiency problems are more common in most herds. The level of both types of errors are interrelated. Practices that increase efficiency can have a negative effect on accuracy. When making management changes to improve heat detection it is important to consider the effects these management changes will have on both efficiency and accuracy.

Measures of Heat Detection

In order to diagnose or manage a heat detection problem in a herd, you have to develop ways of accurately measuring heat detection efficiency and accuracy. A complete and accurate set of records with the ability to quickly summarize information is the most important component to monitoring heat detection. DHIA records, on-farm computer systems and hand-kept records can provide a number of statistics which can be used to evaluate heat detection. Some of the most common measures used to monitor heat detection efficiency include:

1. DIM at First Breeding. DIM at first breeding is a measure of early heat detection. Evaluation in a herd using this measure is dependent on the length of the postpartum rest period the dairy producer gives the herd. With good heat detection the average days in milk at first breeding should not exceed the rest period by more than 22 days (6). (i.e. rest period = 60 Days, DIM at 1st breeding \leq 82 days)

2. Percent Detected Heats (2). Is calculated by the following formula:

$$\text{Percent Heats Detected} = ((\text{Services per Conception} \times 21) / (\text{Days Open} - \text{Voluntary Waiting Period} + 10.5)) \times 100$$

This is a very good measure available from DHIA summary information or can be calculated easily from DHI averages. The one disadvantage is that it is calculated using average days open. Average days open is historical in nature and may not represent what is currently happening in the herd. With good heat detection the percent detected heats should be >70%.

3. Breeding intervals. A breeding interval is the number of days between successive breedings. On the average, cows cycle at 21 days intervals. With good heat detection, breeding intervals should average 21 Days. However, because of missed heats, abnormal cycle lengths and a number of other factors a good average breeding interval would be 24-30 days (6,16). The distribution of individual breeding intervals indicating a herd has good heat detection would be as follows (15):

Breeding interval Length	Percent
<18 Days	10-15%
18-24 Days	55-60%
>24 Days	25-30%

4. Percent confirmed on pregnancy check. This is an easy measure to monitor on herds that have regularly scheduled reproductive health checks, because cows are already submitted for pregnancy determination. Cows that are diagnosed open on a pregnancy exam have probably had heat periods missed. The percent of animals confirmed pregnant will be proportional to the heat detection efficiency (5). However, interpretation of this measure depends on how long after breeding cows are submitted for pregnancy determination. Good heat detection should result in 80-85% of the animals found pregnant with 32-40 day pregnancy exams and 90-95% pregnant with 45-60 day exams (15).

5. 24-Day Chart. A 24-day chart is simply a list of all the open, cycling cows in the herd on a given day (5). As cows on this list are noticed in heat over a period of 24 days they are crossed off the list. At the end of the 24 days you can determine the percent detected heats by the following formula:

$$\text{Percent Detected Heats} = (\text{No. of animals cross of list} / \text{Total No. on list}) \times 100$$

Identifying heat detection accuracy problems can be much more difficult than identifying efficiency problems. No one intends to breed a cow that is not in heat, however this type of error can be a common problem in some herds. A study of 467 dairy herds in the Northeast (11) showed that 30% of herds had a problem with heat detection accuracy. From 10-30% of the cows in these herds were not in heat at the time of insemination. This can have a tremendous effect on conception rate because the conception rate as a result of these inseminations would be 0.

Accuracy errors occur when animals are inseminated based solely on heat detection aids or

secondary signs of heat. There are a few indications that your herd may have such a problem. These include a low conception rate, a high percentage of abnormal length estrous cycles not associated with cystic ovaries or the use of prostaglandins, a lack of uterine tone in cows to be bred, and difficulty in passing the pipette through the cervix. Probably the best method to determine if an accuracy problem exists is to use cowside milk progesterone tests on 20 cows submitted for breeding. No more than 1 in 20 should have high progesterone readings at the time of breeding.

There are a number of cow, environmental and people factors that effect heat detection. These are summarized in Table 1. Heat detection programs need to consider all of these factors in order to maximize heat detection efficiency and accuracy.

Table 1: Factors that effect the heat detection (4).

Cow Factors	Environ. Factors	People Factors
Energy Balance	Temperature	Knowledge of Heat Signs
Body Condition	Ventilation	Heat Checks per Day
General Health	Footing	Time of Observations
Repro. Tract	Grouping Strategy	Intensity of Observation
Dystocia		Responsibility for
Ret. Placenta		Observation
Involution		Reporting of Observation
Infection		
Cyst		

Cow Factors

When considering the cow factors that effect heat detection the first question to ask is "Are the cows cycling?". Immediately following calving cows undergo a period of anestrus. The length of this postpartum anestrus period and the subsequent expression of estrus are determined by a number of factors, including the level of milk production, severity of the negative energy balance, calving complications and health problems. Table 2 is a summary of when first ovarian and estrous activity occur in normal cows following calving.

Table 2: Average Days Postpartum When Ovarian and Estrous Activity Occur in Normal Cows (14).

	Days Post Partum		
	When 70% of Cows Have Activity	When 90% of Cows Have Activity	Average for All Cows
Ovarian Activity	32 Days	40 Days	24 Days
First Estrous Activity	50 Days	63 Days	38 Days

Results from routine postpartum examinations and estrus observation can be compared to values in Table 2 to determine if a problem exists in a group of cows. Upon rectal palpation, 90% of the herd should have major palpable structures (follicles or CLs) on the ovaries by 32 days and standing heats reported by 63 days postpartum. In herds where ovarian and estrous activity are delayed, the incidence of postpartum reproductive disorders and the nutritional program need to be considered. Many of the cow factors that affect heat detection can be improved through fine tuning the nutrition of the dry and milking herds and a comprehensive health program for the prevention and early identification of problem cows.

Environmental factors

Two main environmental factors that effect heat detection are temperature and the type surface on which they are housed:

Temperature; Dairy animals in large operations are housed in facilities which leave them more exposed to the elements. Both high and low temperatures can effect heat detection. Warm temperatures (>80°F) shorten the estrus period and reduce the expression of heat, which result in decreased heat detection efficiency (7). Cold temperatures (<0°F) can have similar effects (7). In addition, cold nighttime temperatures can cause a shift to greater estrus expression during warmer daylight hours.

Footing; The type of surface on which cows are housed and observed for heat has an effect on heat detection. Britt et al. (3) compared heat activity of heifers on concrete versus dirt surfaces. The results in Table 3 show that heifers were in heat for a longer period of time and showed more activity on dirt which should allow for increased detection of heats.

Table 3: Estrous activity on dirt versus concrete surfaces. (3)

	Dirt	Concrete
Duration of estrus (hours)	13.8	9.4
Mounts	7.0	3.2
Stands	6.3	2.9

People Factors

Knowledge of heat signs. The visual detection of estrus depends on the herdperson's ability to detect behavioral changes that take place during heat. These changes are highly variable between cows, which make them difficult to evaluate objectively. It is important for observers to have a knowledge of the various visual signs of heat. The decision to breed or not breed a cow is not always a clear one. A cow standing to be mounted is the only definitive sign of heat. All the other behavioral changes we normally associate with heat are considered secondary signs and have greater rates of error when used to determine heat. Good observers also have the ability to judge the significance of various secondary heat signs they observe in order to make an accurate determination of whether to breed. Some of the more common signs of heat and the errors rates associated with their use are shown in Table 4. Error rates can be reduced when more than one sec-

ondary sign is used to determine whether a cow is to be inseminated or not.

Table 4: Heat signs and associated accuracy errors (12)

Heat Sign	Percent Error
Standing	2.4
Riding other cows	2.5
Rough tailhead	3.3
Unusually active	4.2
Bawling	4.6
Mucus on the vulva	5.2
Not letting down milk	8.0
Fully triggered detector	0.6
Blood on the vulva	7.6
Partially triggered detector	20.9

Heat checks per day. Many cows are in heat less than 12 hours (9). Two to three 30-minute intensive observation periods per day can enable observers to achieve high rates of efficiency (See Table 5).

Time of observations

Studies have shown that 70% of the mounting behavior occurs at night (9). At least one observation time scheduled in the early morning or late evening, when activity is highest, will increase efficiency. One observation should also be scheduled when most cows are laying down. This will enable the observer to check for abnormal or mucus discharge and metestrus bleeding.

Intensity of observations

Intensity of observations has to do with the responsibilities of the observer while heat detecting. Good heat detection requires the undivided attention of the observer. Mounts normally last about 7 seconds (9). This means that observers performing other chores such as feeding, scraping alleys and moving cows, while detecting heats, are more likely to miss brief mounts. Feeding has been shown to reduce mounting activity because estrus animals become more interested in eating than mounting other animals. Estrus activity increases when more than one animal is in heat at the same time (8,9). The number of mounts can increase by more than 300% when two animals are in heat. Intensity of observation can also be increased when estrus animals are left with the herd to stimulate activity in others. Responsibility for observation. On most farms, everyone that comes in contact with the animals is expected to watch for heat. But when the primary responsibility for heat detection and recordkeeping is placed on one individual, there is less confusion and the job is more likely to get done.

Reporting of observation. Accurate records are essential in a large operation. They eliminate confusion and can be used to help observers anticipate future heat periods.

Heat Detection Aids

A number of heat detection aids have been developed to improve heat detection efficiency and eliminate the subjectivity associated with observation. It is important to note that there is no

replacement for good observation. Best results are achieved when heat detection aids are used to supplement, not eliminate observation. Examples of the heat detection efficiency rates which can be expected using various methods and aids are shown in Table 5.

Table 5: Heat detection rates using various methods.

Heat Detection Method	% Detected
Watched 24 hours per day	89
KaMaR heat mount detectors	87
Visual observation - 3X(Dawn, Noon Evening)	86
Continuous videotape	81
Visual observation - 2X(Dawn, Evening)	81
Marker animals	75
Chalked tail heads	71
Two trained dairymen (at milking)	50
Herdsman (at milking)	50
Casual observation	43

Adapted from Grusenmeyer et al. (6)

Tailhead chalk and heat mount detectors

As can be seen in Table 6, the use of tailhead chalk or heat mount detectors can substantially increase heat detection efficiency over more casual methods of heat detection. However, use of these aids can result in an increase in accuracy errors if animals are bred solely based on the aid. Successful individuals will use triggered aids to call additional attention to animals which need closer observation and will base their decision to breed on the additional secondary signs that are noticed.

Marker animals

Deviated or vasectomized bulls, cystic cows and androgenized steers, cows and heifers can be effective methods to increase heat detection efficiency. The introduction of a sexually active animal into a group of cycling females will increase estrus activity. Some of the disadvantages of marker animals are that marker animals tend to get fat on a lactating cow ration and they occupy space which could be used for an additional lactating cow. When marker animals are used there should be one marker per 40-50 cycling females.

Electronic monitoring.

Computerized milking systems have spawned a number of electronic monitoring devices which can be used to aid heat detection. These include the electronic monitoring of individual milk weights and measuring animal activity with the use of pedometers. When a cow comes into heat, milk production will drop slightly below normal levels (9). Most milk recording systems will store a running average of daily milk production and allow the printing of a list of those cows that on

a given day produce significantly below this running average. Such lists can aid in heat detection, however there are number of reasons other than heat which can cause a drop in daily milk production. Research results using pedometers indicate that activity will increase an average of 380% on the day of estrus (10). This makes activity readings an excellent indicator of heat. However, there are questions concerning the cost and reliability of many of the systems available today.

Synchronization

Estrous synchronization with prostaglandins can be used to develop a whole herd program to increase heat detection efficiency. The most familiar of these whole herd programs is the "Monday Morning Program". With this program, healthy cows that have received an adequate rest period following calving are treated with prostaglandins on Monday morning. Cows in the proper stage of the cycle will respond to the treatment and are bred when observed in heat. Heat normally occurs 2-5 days following treatment. Cows that do not respond are reinjected each Monday until they respond or a problem is diagnosed. This type of synchronization program can result in a dramatic improvement in heat detection and reproductive performance. Heat detection improves as a result of prostaglandin use because there is a an increased probability that the treated cow will be in heat in 2-5 days following treatment. Highest conception rates can be achieved when cows are inseminated based on standing heat. These programs require that cows be healthy and cycling normally prior to treatment. Accurate records are needed to avoid abortions, and prostaglandins can only be obtained through a licensed veterinarian. For these reasons it is important to consult with your veterinarian to prior to starting any synchronization program.

Summary

There are a number of factors that influence the heat detection in a herd. Visual observation is a necessary part of any heat detection program. Each dairy farm must develop a program that reduces heat detection errors and must be particularly suited for their facilities, recordkeeping system, management, personnel and daily schedule.

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On-Farm Antibiotic Testing

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On-Farm Antibiotic Testing

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It should be clear to all now that Food Safety Begins On The Dairy and that this premise must be the main thrust of dairy production from this time forward. The consumer will require nothing less than continued production of a safe and wholesome product, and the processing plant wants the residue status managed more closely before the milk reaches the plant. The current regulatory climate has initiated a series of programs that have resulted in an increased possibility that an antibiotic residue violation can be detected when present in the milk. Therefore, we must all begin thinking in terms of Preharvest Food Safety as we manage the dairy herd health status. This necessitates that dairy producers and their veterinarians take more calculated approaches to antibiotic use on the dairy.

The 10-point Milk and Dairy Beef Quality Assurance Program was developed in a collaborative effort between the National Milk Producers Federation and the American Veterinary Medical Association and is designed to promote and document responsible antibiotic use on the dairy. Mastitis occurs on every dairy and is one of the most common diseases that the dairy cow confronts on a daily basis. One area of emphasis in the 10-point program is individual animal testing for antibiotic residues after a specified withdrawal time has been observed post-treatment. The focus of this presentation is to examine the performance of a group of assay systems at the cowside that are currently being employed by regulatory agencies, processing plants, producers and veterinarians on bulk tanks to detect the presence of beta-lactam (β -lactam) antibiotics.

One goal of individual animal testing (cowside tests for antibiotic residues) is to serve as a beneficial aid in the production of high quality milk free of violative levels on antibiotic residues. The reliability of a antibiotic residue assay positive result is important to the dairy industry in assessing appropriate management decisions to assure a safe product is being delivered to the processing plant. Diagnostic tools employed in medical practice are regarded as a means of reducing the uncertainty in diagnosis. In this discussion, the antibiotic residue test assays are used cowside or on individual animal samples to make decisions concerning food safety issues and recommendations. False-positive test outcomes increase the level of apprehension surrounding these recommendations, and put the veterinarian at risk for litigation.

Literature Reports: Performance Of Antibiotic Residue Tests On Individual Animal Samples

The following is only a short review of several reports in the scientific literature that indicate that the antibiotic residue tests may not accurately tell the whole story concerning the presence or absence of antibiotics in the milk. The principles of false-positive or false-negative outcomes also apply to screening for pesticides or herbicides or other chemical contaminants in milk or meat.

1. Egan and Meaney (1984) used three microbial growth inhibition assays, *Bacillus stearothermophilus* var. *calidolactis*, *Bacillus subtilis*, and *Streptococcus thermophilus* Y1 to evaluate milk samples from mastitic cows and heifers, and colostrum samples from heifers. The samples assayed were not obtained from any animal treated with an antibiotic within the previous 21 days. The mammary gland secretions in this study were not heat-treated prior to performing any of the assays. The outcome of microbiological assays included isolates of *Staphylococcus aureus*, *Streptococci*, Coliforms, and no growth. This study documented the presence of natural bacterial growth inhibitors in that the false positive test outcomes ranged from 53.6% to 0.8%, depending upon the assay and the type of sample examined.

2. Seymour, Jones and McGilliard (1988) conducted a study to determine the effectiveness of on-farm screening assays (BsDA, Delvotest P, Penzyme) for the detection of antibiotics in milk and urine. Composite milk samples were obtained from 58 lactating cows that had received a single antibiotic treatment by any route of administration. Samples were obtained 72 hours post-treatment, and sampling continued every 24 hours until all residue tests indicated assay negative.

— Delvotest: Only 78% of the Delvotest results were the same as the BsDA (disc assay); 5% of the Delvo tests were negative when the BsDA was positive; and 17% were positive when the BsDA outcomes were negative.

— Penzyme: Again, only 79% of the Penzyme assay outcomes were the same as the BsDA; 4% were negative when the disc assay was positive, and 17% were positive when the BsDA (disc assay) was negative. Cows treated with cephalosporin, penicillin, and liquamycin produced those results not in agreement with the BsDA results. Although the Penzyme is reported to detect the presence of β -lactam antibiotics in milk, 19 of the 58 animals were treated with non- β -lactam antibiotics.

It is noteworthy that this study did not test mammary gland secretions prior to antibiotic therapy. Therefore, it is unknown what influence the natural inhibitory host defense substances might have had on this study. The pretreatment assay outcomes are necessary in providing the appropriate medical @negative control@ for evaluating the true assay specificity.

Their study also included an initial investigation into the accuracy of the Live Animal Swab Test (LAST). This on-farm screening assay is used to detect potential antibiotic residues in meat before the animal is processed. Urine was obtained from 39 cull dairy cows prior to slaughter and the LAST assay was performed on this set of biological samples. Treatment records from these study subjects were studied to determine their treatment status and if appropriate withdrawal times had been observed. The assay results indicated that 27 of the 39 cows (69%) contained violative residues in their urine, despite the fact that all animals had completed the recommended withholding period specified for each antibiotic administered. It is clear that this test is not specific enough for detecting the presence of antibiotics, as 75% (15 of 20) of the untreated animals in the study were assay positive for antibiotic residues.

3. Tyler et al. (1992) employed several antibiotic residue assay formats in examining the mammary gland secretions from 8 lactating cows with experimentally-induced endotoxin mastitis. The intramammary endotoxin challenge produced a systemic mediator shock and intramammary inflammation. Mammary gland secretions were collected prechallenge and on a scheduled basis for 288 hours after the endotoxin infusion. The proportion of false-positive assay results varied from 0 to 1.00 among combinations of sampling time and mammary secretion evaluated (endotoxin-infused quarter vs a composite sample from the noninfused quarters). The LacTek β -lactam

had no false positive assay outcomes in this investigation, while the Charm Farm assay yielded the highest proportion of false-positive results (0.86). The other two commonly-used residue assays, the Delvotest P and the CITE Probe β -lactam also yielded a high proportion of false positive assay outcomes at 0.45 and 0.48 respectively. The authors concluded that the ability of some of these assays to correctly identify a patient that has not received antibiotics (test specificity) varies greatly among assay kits, and that intramammary inflammation may increase the proportion of false positive assay outcomes.

4) Cullor et al. (1992) performed milk antibiotic residue assays on mammary gland secretions from individual cows. The assays were performed on: a) mammary gland secretions, AM/PM for 14 days, from three cows with experimentally-induced coliform mastitis, b) mammary gland secretions from seven cows with naturally-occurring coliform mastitis, and c) bulk tank milk that was fortified with bovine serum or plasma from antibiotic-free donors. BsDA= disc assay

* Experimentally-induced coliform mastitis: All but one of the assays identified the normal mammary gland defense as antibiotic positive. The patients were not treated with antibiotics. The number of correct assay outcomes are as follows: Charm Farm (10/72), CITE Probe β -lactam (11/72), Delvotest P (10/72), BsDA (50/72), and the LacTek β -lactam (72/72). The data sets from the challenge and control quarters document similar poor performance from all assays. However, the LacTek β -lactam assay correctly identified these samples as not containing antibiotic residues.

— Naturally-occurring coliform mastitis: The LacTek was the only assay that correctly identified the pretreatment quarter samples as not containing β -lactam antibiotics. The percent false-positive test results for the other assays are as follows: Charm Farm (100%), CITE Probe (100%), Delvotest P (83%), and the BsDA (33%).

— Bulk tank milk fortified with bovine plasma: Both the Charm Farm and the CITE Probe assay incorrectly identified the serum/plasma fortified bulk tank milk as being contaminated with β -lactam antibiotic.

5) Van Eenennaam et al. (submitted 1993) performed antibiotic residue assays mammary gland secretions from 172 commercial dairy cows and heifers with cases of mild to moderate clinical mastitis. False-positive assay results were recorded on pretreatment samples, non-treated animals, and samples obtained 21 days after the first treatments had been administered. The percentage of false-positive results was 43.6% (n=839) for the β -lactam CITE Probe, 37.7% (n=839) for the Delvotest P, 81.7% (n=387) for the Charm Farm assay, 2.6% (n=836) for the LacTek β -lactam test, and 18.8% (n=819) for the disc assay (BsDA). The study also documented apparent problems with false negative outcomes for some of the test kits. One example of mention is at milking quarter sample 4, the CITE Probe β -lactam had a false-negative rate of 15.3%.

What are the consequences of false-positive antibiotic residue test results?

A). They lead to unwarranted waste of milk and economic loss.

B). The socioeconomic impact can harm the dairy industry if antibiotic tests with inadequate biomedical specificity, the ability to correctly identify an untreated cow, are indiscriminately used to test individual cow samples. The false-positive outcomes create a mis-

trust between the consumer and the producer, veterinarian, and regulatory personnel, because they are interpreted that the safety of the milk is not being adequately monitored at the level of the bulk tank.

C). False-positive residue test results can lead to the inaccurate conclusion that a significant proportion of normal dairy cows are delivering residues into our milk supply each day.

D). In the face of genuine efforts made by the dairy and medical industries to produce a safe and wholesome dairy product, widely publicized negative reports of residues in milk that are based upon inappropriately validated and applied technologies will be the reports that the consuming public remember.

E). The welfare of the individual dairy cow is at risk because too many positive assay outcomes after recommended withdrawal times have been followed will result in her being sent to the slaughterhouse. In this case, the false positive assay outcomes result in the untimely death of the dairy cow.

F). Eventually, this problem will have a negative impact on international trade because of the misconception that too many antibiotics are being administered to individual animals and are not being detected at the meat processing plant.

Other adverse consequences could be listed. However, these should be sufficient to raise concern that the approach of erring on the safe side sounds good at first, but doesn't really serve the purpose of addressing all aspects of producing dairy products free of violative residues.

Recommendations: Producer, Practitioner...Test the Tests

Some Practical Ways to Test the Tests: The following is a modified version of the four phase validation program suggested by me in other publications (6). We'll call them Phase I-P, and Phase II-P to designate the practitioner/producer or practical phase of the antibiotic residue test kit evaluation.

Test the Tests!

Phase I-P of the suggestions could be easily accomplished by the practitioner in the following manner:

* Obtain 25 ml of plasma from each of 5 cows that they can certify: 1) are in normal physical condition, and 2) have not received any therapy for at least 30 days prior to collection time. * Pool the plasma from these animals and use it to spike the bulk tank milk. * Bulk tank milk: must have a SCC below 1 million/ml and the veterinarian can document that no treated animals went into the bulk tank that day. This sample must be fresh each day that they use it to test the tests, because some assays cannot be used on frozen milk samples. * Make up the following sample sets to test β -lactam residue assays:

- 1) Zero control (100% v/v bulk tank milk): [v/v= volume/volume]
- 2) 10% v/v plasma and 90% v/v bulk tank milk
- 3) 20% v/v plasma and 80% v/v bulk tank milk
- 4) 40 % v/v plasma and 60 % v/v bulk tank milk
- 5) Positive control: mix 1.0 ml of a β -lactam antibiotic in 3 ml of bulk tank milk

* Test the test kit by running it in triplicate on each sample set according to manufacturer recommendations.

* The residue kit should yield a assay negative outcome on the zero control milk and an @assay positive outcome on the positive control sample. * An assay positive outcome on any one of the other sample sets is suggestive that the test kit possesses an inappropriate assay specificity, and it may be unable to correctly identify that a sample does not contain β -lactam antibiotics.

Phase II-P of the test kit evaluation may be accomplished as follows:

* Collect pretreatment mammary gland secretions from 30 individual animals that have been diagnosed as having clinical mastitis in one quarter. The procedure for the sample collection is provided below. * Sample 1: Is composed of premilking mammary gland secretions from the mastitic quarter (5 ml) * Sample 2: Is made from 5.0 ml aliquots of premilking mammary gland secretions from each of the 3 remaining normal quarters. * Test the test by running it in triplicate on each sample set according to manufacturer@s recommendations on the following sample sets:

- 1) Zero control (100% v/v bulk tank milk)
- 2) Positive control: mix 1.0 ml of a β -lactam antibiotic in 3 ml of bulk tank milk
- 3) Sample 1: pre-treatment milk from the infected quarter
- 4) Sample 2: pre-treatment milk from the composite sample of the 3 normal quarters

* The residue kit should yield a assay negative outcome on the zero control milk and an assay positive outcome on the positive control sample. * An assay positive outcome on any one of the other sample sets is suggestive that the test kit possesses an inappropriate assay specificity, and it is unable to correctly identify that this clinical case of mastitis has not been treated with β -lactam antibiotics.

This set of experiments is not difficult to perform. Collaborate with your veterinarian or Extension Specialist on this important issue. If the test(s) you're currently using doesn't do a good job and incorrectly identifies the cow as having antibiotics in her milk before any treatment has been administered, ask yourself "Is this really a good tool to make accurate management decisions?" Afterall, it's your dollars that may be going down the drain, and your cow that's going to be culled.

Conclusions

Mastitis is the single most common disease syndrome in dairy cows. Any residue test that does not account for mammary gland inflammation and other host defense mechanisms in its assay format contains a serious scientific and practical defect. If the test cannot differentiate between normal host defense and the presence of antibiotics in the milk, it is indefensible as either a screening or diagnostic assay under any circumstances. Remember, the correct definitions for test kit sensitivity and specificity under medical diagnostic field conditions are as follows:

Specificity (Biomedical): The probability of correctly identifying true-negative (non-treated) animals (Laboratory definition of specificity: the ability to differentiate between penicillin and tetracycline).

Sensitivity (Biomedical): The probability of correctly identifying true-positive (antibiotic treated) animals (Laboratory definition of sensitivity: the ability to detect parts per million (ppm) or parts per billion (ppb), etc.)

The laboratory definitions can not appropriately be applied to cowside tests, or any other biological sample (e.g. bulk tank milk, etc.)

It has been previously documented in this presentation that false-positive antibiotic residue assay outcomes are a serious problem. These data sets clearly demonstrate that several antibiotic residue assays that yield false-positive outcomes are on the market today, and can create unwarranted concerns for regulatory personnel, veterinarians, consumers, and dairy producers.

Additionally, when some of the test kits with various assay formats are employed on individual cow mammary gland secretions, they cause milk to be discarded unjustifiably far beyond current regulatory withdrawal times and adversely affect the way the producer and veterinarian may employ necessary medications for the welfare of their patient. It is clear that under these circumstances both the producer and the veterinarian could be falsely accused of not following regulatory guidelines and suffer profound adverse consequences due to this critical defect in the residue assay.

A thorough evaluation of all data available on appropriate research and development of the @residue test@ must be sought before recommendations are put forth. Remember, the test kit validation procedures previously used to allow these kits on the market is probably still in place, and is not likely to be appropriately modified in any substantial manner. Performance of an assay in spiked samples of normal milk with parent compound of an antibiotic is not the same as treating an active case of mastitis or other form of systemic disease and then determining when the patient may safely go back into production. This method of assay validation has little, if any biological relevance.

The 10-point Milk and Dairy Beef Quality Assurance Program is a valuable tool to aid in assuring the consumer of maintaining a safe and wholesome product. The producer and veterinarian can maintain appropriate on-the-farm controls over the use of medications by employing current regulatory guidelines and by supplementing them with the other portions of the 10-point plan. Dairymen, milk processors, and those who advise them need more specific tests to help them assure consumers of a safe, residue-free milk supply.

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Immunology
And Vaccines —
Where We Are
And Where We
Are Going

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Immunology And Vaccines — Where We Are And Where We Are Going

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The immune system is the focus of intense current research in both veterinary and human medicine. This research spans the realms of possibilities from cancer treatments to AIDS vaccines. Many of the advances in future treatments of diseases will come from chemicals with their derivatives in the immune system. In order to be a good manager of the large dairy herd, you must be able to discuss vaccination programs and make informed decisions with your veterinarian. A basic understanding of the immune system and how vaccines work is necessary. A knowledge of the limitations of vaccines is essential when we access large herd disease dynamics.

There are some important concepts to consider when making these decisions. These concepts often change as we look at the different organisms that can attack the cow. Different diseases are handled differently by the immune system.

What does immunity really mean? For all practical purposes; if a cow is healthy and is exposed to a disease agent, the animal gets rid of the organism with a minimal disruption of body functions. The immune system often moderates disease rather than preventing infection.

As we look at the immune system, it is divided into two distinct parts. The innate immune system is composed of cells and chemicals that cannot be enhanced by exposure or vaccination. It is the first line of defense and includes the mucous membranes and cells of the skin. The adaptive part of the immune system can be improved by vaccination or exposure. This part of the immune system does have indirect effects on the innate immune system.

The adaptive part of the immune system is likewise divided into two sections. The cell mediated wing (CMI) and the humoral wing. They are governed by T cells and B cells respectively. Both B cells and T cells belong to a group of cells called lymphocytes. They look identical since they come from a common precursor. Special tests are required to differentiate between the two cell types. However, both wings have dramatic differences in how they function.

CMI is the part of the immune system receiving the most research today. CMI is integrally involved in the protection and clearing of most viral infections. For some viruses, such as IBR, it is the primary source of protection as antibody levels do not indicate protection. CMI is also a primary source of cancer control.

As stated previously, CMI is regulated by T cells. There are basically three T cells involved in the immune response:

Helper and suppresser T cells act as primary mediators of the entire immune system including antibody production. This is done through the release of chemicals by these cells. These chemical messengers have effects on other cells in the immune system, attracting them and making them more efficient. These chemicals can also have an effect on virus replication and the ability of viruses to infect a cell.

Killer (cytotoxic) T cells are also driven by antigens invading a cell. They have the ability to recognize infected or cancerous cells and destroy them.

CMI is a powerful regulator of the entire immune system including the humoral wing. CMI is difficult to stimulate with killed vaccines and killer T cells cannot be primed with a killed vaccine. In veterinary medicine measurement of CMI stimulation is a recent advance. Although available for human testing in veterinary medicine, these are only used in research at this time.

The humoral wing of the immune system is concerned with antibody production. This part of the immune system is easy to check and is often called serology or titers. When the veterinarian pulls blood to look for diseases he is often checking antibody levels. The problem is that antibody levels have been associated with protection which is often not true. The humoral wing is run by B cells. When the B cells are stimulated by antigens and chemicals from helper T cells they can become a memory cell or a plasma cell. Plasma cells then make antibodies. These antibodies can be manufactured at the rate of 300 per second by a plasma cell. When we measure titers we are determining the amount of a specific antibody in the bloodstream. There are four basic classes of antibodies found in the bloodstream of cattle. They are:

- IgG: the predominant antibody in the bloodstream. It is small and can easily leave the bloodstream to reach infected areas.
- IgM: the largest antibody and the first antibody made in the immune response. Its large size makes it more difficult to move out of the bloodstream.
- IgA: the predominant antibody of the mucous membranes. It is a secretory antibody and is the first line of defense against many diseases. It is difficult to stimulate with killed vaccines and easily stimulated by orally and intranasal vaccines.
- IgE: the antibody involved in allergic reactions.

It is possible to stimulate antibodies that are not protective or, in some instances, are harmful to the animal. One of the goals of vaccination is to have an animal recognize a virus or bacteria and make the protective antibodies. Then we can neutralize the effects of the disease.

There are several factors that can affect the immune system. We need to be constantly aware of the factors that add stress onto the cow if we are to maximize a vaccine's potential. Two important stressors are calving and heat. Vaccination should be avoided until seven days post calving to avoid calving related stress on the fresh cow. In temperatures over 78 degrees Fahrenheit the Holstein breed will begin to show some mild heat stress. At temperatures above 90 degrees Fahrenheit vaccination should be performed in the cooler hours of the day.

The area getting most of the research now is micro-minerals. Deficiencies in micro-minerals not only affect the immune system by not allowing it to respond properly to a challenge of vaccination but may increase the likelihood of reactions to vaccines. The primary micro-minerals involved are Copper, Iron, Zinc, and Selenium. We also see Vitamin A and Vitamin E involved in this scenario.

One thing to keep in mind is that challenge and protection are not constant steady state items. We like to think that when we vaccinate an animal, it has a certain level of protection. However, the cycles of the animal affect the level of protection. The same is true with the amount of exposure to a pathogen. What we try to do with vaccination is to widen the gap between challenge and protection, thereby making it more difficult to get disease. It does not mean that when you vaccinate you will never get the disease.

It is important to follow the label directions for administering vaccines. This brings us into a discussion of modified live versus killed vaccines. Killed vaccines and modified live BRSV act as a killed vaccine, require a booster shot before protection is complete. The first time we give a vaccination we get what is termed the primary response. This response is fairly short lived and is not very strong. It is also composed mainly of IgM. The response seen after a booster shot is called the secondary response or anamnestic response. This response is much stronger and long lived and is primarily IgG. Also, there is much more memory made in response to the booster shot. If we give our booster too early, we won't get the anamnestic response; and if we wait too long to give it, we go back to it acting as a primary shot not as a booster. With modified live vaccines, since the virus or bacteria is growing in the animal, it goes from the primary into the secondary response without needing a booster.

What are we doing with vaccination? We are tricking the immune system to think that it has been attacked by that disease. The closer a vaccine approaches the natural, wild virus, the stronger the immune response is and your animal has better protection.

**Effectiveness Of
Premilking Udder
Preparation Practices
On Milk Quality And
Udder Health**

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Effectiveness Of Premilking Udder Preparation Practices On Milk Quality And Udder Health

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The objectives of good premilking udder preparation are to produce high quality milk — clean and normal and to minimize mastitis by maintaining good udder health, as well as achieve optimum milk production and milking efficiency. Methods and effectiveness of premilking preparation vary among dairymen; however, there are principles and practices that must be combined to achieve the best results. This paper summarizes a series of recent research trials at Cornell, along with other research reports and field experiences as a basis for making recommendations about udder preparation procedures.

Since teats are commonly contaminated with bacteria and a certain amount of manure, dirt and bedding at the time of milking, procedures for udder preparation should ensure that teats are manually cleaned and thoroughly dried before machine attachment. If the preparation is not done effectively, milk quality will be lessened due to higher bacterial counts and more sediment in the milk. Since the risk of new mastitis infections is related to the number of bacteria exposed to the teat, good mastitis control should be practiced to reduce the bacterial population on the teats as much as possible. To the extent this can be achieved by effective udder preparation before milking, reduces the likelihood of bacteria entering the teat canal and udder under some circumstances that can occur during machine milking (i.e. liner slippage, machine removal with vacuum at teat end).

Although methods and effectiveness of udder preparation have always varied among dairymen, the trend has changed during recent years due to increased concern about environmental-related mastitis (i.e. *Streptococcus* species and coliforms) and milk quality, and to changes in milking systems. Our research suggests that udder surfaces should be dry (even if dirty) and teats should be cleaned and dried before milking. Research indicates that wetting any portion of the udder above the teats without thorough drying will result in dirty, bacteria-contaminated water draining into the top of the teat cup liner during milking, thus lowering milk quality and increasing the risk of mastitis. When water is applied to the udder surface, time needed to dry the udder manually or allowed for surfaces to drip dry to prevent water drainage is excessive and not efficient. However, thoroughly drying a wet udder during the time available in most milking routines is impractical and unlikely to be done correctly. If drainage occurs during milking, water will collect around the teat at the top of the liner which suggests udder preparation procedures need to be improved.

Dryness is possible and practical to achieve when only the teat surfaces are wetted. Air drying of teats is not satisfactory for maximum hygiene (bacterial counts and sediment in milk). The physical force of manual drying with an individual paper towel for at least 10 seconds can remove up to one-half of the bacterial population on teats and thereby is more effective for maximum hygiene and milk quality than is air drying of wetted teats. Another advantage of drying teats is

that teat cup liners are less likely to initially slip or fall off. The type of towel (paper, cloth) that should be used to dry teats depends on the amount of water used, the cleanliness of the teats, and the way the towel is used in drying the teats. In some herds, more absorbent towels may be needed to achieve the objective of clean, dry teats.

To avoid potential problems from wet udders and teats and the extra time needed for drying, some dairymen have followed 'dry prep procedures', which in some cases means wiping teats with a dry hand or dry towel, but in other cases means no prep at all. While a poor job of washing and inadequate drying of teats and udders may be no better (and in some cases, worse) than no prep at all, the best results are achieved from a good job of cleaning and drying teats. Results of recent research comparisons at Cornell showed that even with cows whose teats were visibly clean, there were 3 to 16 times more bacteria in milk from either "no prep" cows, "wet udder" cows, or "dry wipe" cows than from "properly prepped" cows. The best preparations in these comparisons were using either (1) a hose and water with sanitizer directed on teats only, plus hand scrubbing or manipulation of the teats during washing followed by manual towel drying; or (2) using a wet paper towel in cleaning the teats only followed by manual towel drying.

In light of milking efficiency (cow throughput per worker), manual drying may not be desired especially in large herds. The practice of manual drying may not be needed if the herd somatic cell count and the incidence of clinical mastitis are low, and milk quality is very good. However, if any one of these parameters are not within the desired range, or the dairyman desires to minimize risk of future problems, then manual drying should be done to improve the overall effectiveness of the udder preparation.

Research results have shown that udder wash sanitizers have marginal benefit in reducing bacterial populations in milk. The small benefit is most consistent when sanitizers are used with water hose preparation procedures. Their limited benefit is likely due to low germicidal activity, method of application (inadequate dispensing of solution, and covering of teats), short contact time on the teat skin, and the relatively greater effect from physical action that usually occurs during cleaning and drying in reducing bacterial populations in milk and on teat skin. Therefore, udder wash sanitizers should not be used with the thought that they kill a major portion of bacteria on teat skin. Sanitizers may be of somewhat greater benefit in killing bacteria in water lines, on milkers' hands, and in milking machines. Recent Pennsylvania work indicates that certain bacteria (i.e. *Pseudomonas aeruginosa*) may live in water lines even with a sanitizer present. Thus, they suggest that flushing water from the wash hoses before their use at each milking may reduce exposure of the cows to the organism.

Cornell work indicates that predipping teats, plus manual drying with a paper towel, is as effective as a good job of washing teats with water (hose or wet towel) plus manual drying, in reducing bacteria on teat skin and in milk. Recent research results from Cornell and Vermont show that predipping can reduce new mastitis infections 43-51% more than from a good job of washing and drying teats. With predipping, manually drying all four teats with an individual paper towel is not only essential for reducing bacteria and sediment, but also to avoid a problem of disinfectant residue in milk. In other words, if manual drying is not done correctly, predipping should not be practiced. If teats are contaminated with dirt or manure whereby predipping with subsequent drying does not physically clean the teats, then teats should be washed prior to predipping. Washing should occur only when the benefit of achieving cleaner teats can be realized which depends on the cleanliness of teats and the procedures used in applying the predip and drying.

Dairymen should only use dips with proven efficacy; manufacturers should provide these data, if available. The disinfectants should be applied via a dip container or sprayed on the teats. For

proper coverage and effectiveness from dipping or spraying, an effort should be made to ensure that all teats are covered with the dip. Too often, the teats on the opposite side from the milker are inadequately dipped or sprayed. In New York, three to four gallons of teat dip are used with dipping both pre- and postmilking, compared to four to six gallons used with spraying. The amount of dip used should be monitored carefully.

A minimum of 15 to 20 seconds for skin contact time is needed for a predip teat disinfectant to effectively kill bacteria. When the environmental related mastitis pathogens are at a high level on the teats, a skin contact time of 30 seconds may be needed to reduce bacterial numbers on the teats, thus, reducing the risk of environmental mastitis.

A good job of predipping with subsequent manual drying may decrease cow throughput by 8 to 12% compared to the use of wash and drip pens with no udder preparation in the parlor. This decrease would not be as great when forestripping, cleaning, or drying of teats is practiced in addition to the use of wash and drip pens. Generally, the operator work routine time per cow for predipping is 3-6 seconds, manual drying is 6-8 seconds, and forestripping is 4-7 seconds. Even if predipping with manual drying takes longer, the benefit of reducing environmental mastitis by 50% may justify the practice, especially during wet muddy weather and if the cow's teats (and udder) are wet when entering the parlor. The need for the benefit of predipping may be monitored based on the incidence of both subclinical and clinical environmental mastitis in the herd.

Predipping with manual drying may not be sufficient for good milk letdown for low producing cows immediately after machine attachment. Thus, the automatic detachors may have to be overridden during early part of each cow milking. Forestripping may enhance the milk letdown, if necessary.

Undiluted udder wash sanitizers should not be used as premilking disinfectant dips, since they are not formulated for this purpose and do not have the same germicidal activity level as formulated teat dips. If concentrated sanitizers are used as dips, teat tissue damage may result.

We suggest to producers that forestripping (4-7 seconds) may not be necessary in herds that primarily experience environmental-related mastitis. Clinical cases of environmental mastitis (organisms other than *Strep agalactiae*, *Staph aureus*, and *mycoplasma*) can be detected through methods other than detecting milk for clinical mastitis signs. If forestripping is practiced, we recommend that it occur prior to cleaning or disinfecting the teats (predipping). Certainly, forestripping after cleaning or drying of teats may deposit bacteria and dirt back on the teats. Also, forestripping while a disinfectant (predip) is on the teats, may expose the milkers' hands to prolonged chemical exposure.

It is not surprising that the critical aspect in the overall effectiveness of premilking preparation procedures is how well they are performed. Superficially relating to the recommended steps does not guarantee a satisfactory job. Washing with a hose and water is often done with the intent of only wetting the teat surfaces, but in reality the udder surfaces are also wetted. The side surfaces of teats during washing usually are cleaned relatively well, but the teat ends may not be. The greater benefit from predipping in herds may be because the dip consistently comes in contact with the teat end experiencing environmental mastitis and better kills bacteria at the teat end than the use of the water hose or wet towel washing procedures. Management needs to select the proper preparation procedures for the given herd conditions and then ensure that the preparation is done correctly on a continuous basis to achieve best results for high milk quality and good udder health.

Cows and teats are best kept clean between milkings by environmental management rather than routinely trying to get dirty teats clean at each milking. This requires attention to stall design,

bedding, and condition of corrals. Clean cows contribute to high quality milk, better working conditions, and reduce exposure to environmental types of mastitis-causing organisms. Cleanliness of cows at milking time certainly can modify the effectiveness of udder preparation, and may be just as important as udder preparation. A high level of bacteria in the bulk tank is highly correlated with cooling of milk, cleanliness of the milking equipment, degree of udder preparation, and bacterial numbers in the bedding. Thus, udder preparation and bedding management influence milk quality as well as the risk of machine-induced infections.

Effective cleaning of teats only (including the teat ends) with water (water hose or wet towel) or a disinfectant predip, followed by manual drying with dry paper towels, is needed to reduce bacterial numbers and to reduce sediment and chemical residues. Regardless of the udder preparation practiced, the bottom line is to ensure clean, dry teats at machine attachment time.

Results of Cornell Experiments on Udder Preparation

The following series of tables, based on recent research at Cornell, give dramatic evidence to the importance of proper udder preparation in decreasing bacteria on teats and in milk, and in reducing new mastitis infections. The main points from each of a series of research trials are highlighted here:

Table 1. Bacterial counts in milk associated with the use of the water hose in wetting both the udder and teat surfaces.

Procedures on both <u>UDDER</u> and <u>TEAT</u> surfaces			Bacteria in Milk ^a	Primary factor
<u>Water hose</u>	<u>Wash sanitizer</u>	<u>Manual drying</u>	<u>% Change</u>	
X			+ 13	Water Drainage
X	X		-10	Sanitizer
X	X	X	-68	Manual drying

^aPercent change of bacterial in milk compared to no preparation

- Wetting the udder surface, and teats, without adequate drying, can increase bacteria in milk due to drainage from the udder surface
- An udder wash sanitizer has relatively small benefit in reducing bacteria in milk because of its low germicidal concentration, method of application and short contact time on the skin.
- Manual drying is of major benefit in reducing bacteria, due to 'physical action' of wiping as well as 'drying'.

Table 2. Bacterial counts in milk associated with cleaning teats only.

Procedures on <u>TEATS</u> only					Bacteria in Milk	Primary factor
<u>Dry towel</u>	<u>Water hose</u>	<u>Wet towel</u>	<u>Wash sanitizer</u>	<u>Manual drying</u>	<u>% Change</u>	
X					-38 ^b	Physical effect
	X				-65	Drainage from
	X		X		-67	udder surface
	X			X	-76	Drying
	X		X	X	-88	Drying plus sanitizer
		X			-71	No drainage from
		X	X		-62	udder surface
		X		X	-79	Drying
		X	X	X	-78	Drying

^aPercent change of bacteria in milk compared to no preparation.

^bResult depends on "dirtiness".

- Premilking preparation should wet and clean teats only.
- 'Dry wiping' can remove some bacteria (largely as part of sediment) due to physical action. The degree of result depends on how dirty teats are. Dry wiping alone is never the best procedure
- Drying of teats prevents movement of bacteria in water.

Table 3. Milk sediment associated with udder preparations.

Procedures on <u>TEATS</u> only					Milk Sediment ^a	Primary factor
<u>Dry towel</u>	<u>Water hose</u>	<u>Wet towel</u>	<u>Pre-dip</u>	<u>Wash sanitizer</u>	<u>Manual drying</u>	<u>% Change</u>
X						-38 ^b
	X					-29
		X				-56
		X			X	-57
			X			-4
			X		X	-42

^aPercent change of milk sediment compared to no preparation (2.4 g/l).

^bResult depends on dirtiness.

- Physical action (i.e., scrubbing with a liquid during washing or drying after disinfectant [liquid] application) is a significant factor in reducing sediment in milk

Table 4. Bacterial counts in milk associated with various udder preparations.

Procedures on <u>TEATS</u> only					Bacteria in milk ^a	Primary factor
<u>Water hose</u>	<u>Wet towel</u>	<u>Predip</u>	<u>Wash sanitizer</u>	<u>Manual drying</u>	<u>% Change</u>	
X					-4	No drying
X			X		-3	
X				X	-39	Drying
X			X	X	-49	
	X				-27	Liquid scrubbing
	X		X		-30	no surface drainage
	X			X	-63	Liquid-
	X		X	X	-68	scrubbing-drying
		X			-34	Germicide
		X		X	-54	Germicide-drying

^aPercent change of bacteria in milk compared to no preparation.

Table 5. Bacterial counts on teat skin associated with various udder preparations.

Procedures on <u>TEATS</u> only					Teat skin bacteria before machine-on	Primary factor
<u>Dry towel</u>	<u>Wet towel</u>	<u>Predip</u>	<u>Wash sanitizer</u>	<u>Manual drying</u>	<u>% Change</u>	
X					-4	
	X				-40	Scrubbing
	X		X		-40	
	X			X	-77	Drying
	X		X	X	-85	
		X		X	-85	Drying

^aPercent change of bacteria in milk compared to no preparation.

* These experimental results (Tables 4 & 5) indicate that predipping with a postmilking teat dip plus drying is as effective as using water (hose, wet towel) and sanitizer plus drying in reducing bacteria in milk and on teat skin.

* Drying is beneficial as a result of physical action and for removal of bacteria-laden water and chemical residues

Table 6. Iodine in milk for different premilking udder treatments.

Predip	Wiping and drying of teats	Postdip	Iodine in Milk	
			Increase ^a	Content ^a
<u>1.0 % Iodine</u>		<u>1.0 % Iodine</u>	<u>%</u>	<u>p.p.m.^b</u>
+	+	-	29.4	.328
+	+	+	56.5	.485
+	-	-	349.8	1.067

^aIncrease compared to control period without iodine dips.

^bWith no iodine teat dips (either pre- or postdip), milk iodine was .285 ppm due to iodine from feed.

* A 1% iodine dip used here increased milk iodine by 29% as a predip and by 56% as a pre- and postdip; the latter may be attributed to iodine absorption through the skin between milkings and teat surface contamination. In both cases, milk iodine level was within an acceptable range.

* Teats that are predipped must be wiped and dried thoroughly to avoid residues in milk. As illustrated here, not wiping off a 1% iodine predip resulted in a 350% increase and an unacceptable iodine content in milk.

Table 7. Milk iodine residues in herds practicing iodophor premilking teat disinfection.

Predip	Wiping and drying of teats	Postdip	Iodine in Milk	
			Increase ^a	Content ^b
<u>0.1 % Iodine</u>		<u>0.1 % Iodine</u>	<u>%</u>	<u>p.p.m.^b</u>
-	-	+	13.6	.292
+	+	+	16.0	.294
<u>1.0 % Iodine</u>		<u>1.0 % Iodine</u>		
-	-	+	29.2	.336
+	+	+	39.6	.388

^aIncrease compared to control period without iodine dips.

^bWith no iodine teat dips (either pre- or postdip), milk iodine was .260 ppm due to iodine from feed.

* These results are from a field trial with 7 commercial dairy herds totaling 560 cows. Lower iodine concentration in a teat dip as well as thorough wiping and drying helps keep lower iodine residues in milk. This is important as responsible action to avoid contamination of milk. Increased iodine levels in milk is a human health factor.

Table 8. Effects of udder preparation on the rate of new intramammary infections under experimental bacterial challenge conditions. (Cornell Study)

NONE	Udder Preparation		Manual drying	Postdip	New intramammary infections		
	Wet towel	Predip			Quarters	Reduction	
					-----%-----		
X				.25 % Iodine	26.8		
	X		X	.25 % Iodine	15.2	43.3 ^b	
		X	X	.25 % Iodine	8.9	66.3 ^c	41.0 ^d
(0.1 % Iodine)							

^aExperimental challenge, teats dipped in Strep uberis broth 3 hours before milking

^bDifferent from no preparation.

^cDifferent from no preparation.

^dDifferent from wet towel, drying.

Table 9. Summary of new intramammary infections with environmental pathogens in predip studies in four commercial farms. (University of Vermont)

Treatment	Infected quarters			Quarters	Reduction
	Streptococcus species	Coliforms	Total		
	-----no.-----			-----%-----	
Wet towel plus drying	31	41	72	13.0	
Predipping plus drying	18	21	39	6.3	51.5 ^a

^aDifferent from wet towel, drying.

In terms of mastitis control, these experimental results (Tables 7 and 8) clearly show that an effective job of pre-milking teat preparation is very important.

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When Is A.I. Profitable?

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LAS VEGAS NEVADA

When Is A.I. Profitable?

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The answer to the question posed by the title is actually quite simple. The truth is that AI is profitable almost all the time that heifers are to be retained as future replacements. The remainder of the paper will be devoted to documenting this bold statement and the few exceptions to it.

One of the few exceptions to the superior profitability of AI would occur if replacements of equal quality can be purchased cheaper than yours can be reared. Whether AI should be practiced in such a situation would depend on its effect on sale price of calves a few days old compared to any extra costs of AI over natural service.

Another caveat is that common sense is used when buying and using semen. Buying semen from the currently "hot" and usually overpriced bulls to breed ordinary grade cows is not sensible. Despite the hype that usually surrounds such bulls, few if any will sire the most profitable commercial replacements.

Using expensive semen to inseminate cows that are likely to be culled before they calve again does not fall within my definition of common sense either. Breeding heifers to bulls known to cause a high percentage of difficult births is in the same category.

One of the false ideas used to support natural service is that it is practically free. All direct costs of using bulls are rarely considered, let alone the indirect and opportunity costs. Research several years ago at the University of Wisconsin by Shook showed that the direct costs in a typical herd averaged \$18 per service. With the larger herds typical today, this may be a few dollars too high, but natural service is still costly. Low conception rates and diseases may also be obtained from such bulls.

For AI to be profitable, management adequate to detect accurately at least 40 to 50 percent of true heats is essential. Without this minimum level of accuracy, a high percentage of cows will be missed until their lactation is advanced.

A common misconception is that 70-80% of heats must be detected to use AI successfully. Actually, only the best managed herds reach that level. Studies by Blake and colleagues at Cornell showed that increasing accurate heat detection rates beyond 50% was often unprofitable. This occurred when costs to obtain the extra accuracy amounted to more than a few dollars per additional cow detected.

Accurate identification of individual cows is also essential. Otherwise, cows may be misclassified as in heat when they are not. Inaccurate identification of the cows truly in heat has drastically unprofitable effects. Results will be unnecessary costs without additional pregnant cows. Breeding cows not in heat may also be harmful to the future reproductive success of a cow.

Consequences of inadequate or inaccurate heat detection will be costly. Long calving intervals will be common. Yields of many cows will decrease to unprofitable levels before they

become pregnant. Combined, these may negate many of the favorable aspects of AI.

Limitations of facilities may affect the profitability of AI. When it is expensive to catch and restrain cows for breeding, costs per pregnancy increase. If catching and restraint upsets cows, conception rate can be reduced. This may reduce the pregnancies resulting per AI service, thereby increasing their cost. New Zealand, which has one of the lower fixed costs per cow in the world, breeds nearly 70% of its cows by AI. This shows that adequate facilities for AI need not be expensive.

Another common misconception is that conception rate to AI service must be over 50% for AI to be profitable. At 40% conception, only 34% of cows will require three or more services. Only 10% will need more than four inseminations. The realistic upper limit of conception rate is only 65-70% with natural service to a highly fertile bull. For example, pregnancy rate is rarely more than 80% in cycling cows exposed to a fertile bull for 50-60 days. Usually higher conception rates will make AI more profitable, but an outstanding conception rate is not necessary to make AI more profitable than natural service.

The opportunity costs of using natural service are well known. The USDA summaries released after every sire summary show that the net value of the extra milk of an AI-sired cow is worth at least \$25 over feed costs in each of her three or more lactations. This occurs because feed costs for maintenance and fixed costs are nearly the same for every cow of the same age and body size. The total additional net of \$75 per cow over her life should be mostly profit because costs of AI can be kept near that of natural service by good planning and management.

How much one can profitably pay per unit of semen over the cost of natural service has been the subject of much research and discussion without an answer that satisfies everyone. General agreement has been reached that the expected net financial return from the resulting heifers is the best method of computing how much can be paid. Disagreement still remains on details of some of the minor costs and returns to include.

The main factors affecting expected or predicted income are:

1. Expected additional lactation yield of a cow resulting from the semen of a particular bull.
2. Future values of milk and its components.
3. Expected length of a resulting cow's life.
4. Conception rate of semen.
5. Values of any traits such as mastitis resistance, milking ease or speed, calving difficulty, etc., that reduce costs over that of an average cow.

The main factors affecting variable costs are:

1. Expected future feed cost per unit of milk and components.
2. Minimum cost of getting a cow pregnant by AI minus cost of pregnancy from natural service.
3. Extra cost of semen from a particular bull necessary to obtain a milking heifer, discounted for the time value of money.
4. Opportunity costs from any milk lost due to calving intervals longer than those from natural service.

You may note that only the additional cost of semen is affected by conception rate. Whether the cow will be kept to calve, calf liveability, and all other costs affect AI and natural service equally.

Comparing Profitability Of AI And Natural Service For A Herd

A simple but reasonably accurate comparison of the relative profitability of AI and natural service breeding may be obtained by the following steps. Estimate or compute the following:

1. Expected value of milk and its components in your future milk market for a lactation from an average daughter of the AI bulls available, minus the values for an average natural service daughter. Multiply by 3.0 for lifetime value.

2. Add in the value of superiority for additional traits of the AI bulls, including udders, feet, and longevity. Multiply by 3.

3. Compute value for feed cost for the extra milk, which usually varies from 35 to 40% of the milk value.

4. Compute the costs of getting an AI-sired heifer minus the cost of a naturally sired one.

The approximate profitability of AI for your herd is simply:

* Number of replacements per year x (1 + 2 - 3 - 4), or * Number of replacements x (milk \$ + \$ value of other traits

- feed cost for extra milk
- extra cost of AI daughter)

For example, suppose the following costs and returns are appropriate for your herd:

a. Daughters of first-proof AI young bulls average about 400 lb more milk than those of first-proof natural service bulls from USDA summaries. This is worth at least \$40.00. For a lifetime this equals \$120.

b. Suppose superiority in other traits adds \$15 per cow.

c. Suppose feed costs are 40% of milk, or \$48.

d. Suppose the extra cost of obtaining an AI daughter is \$50. This would include the extra labor and supplies over natural service costs.

The net value of AI is now \$120 + \$15 - \$48 - \$50, for an advantage of \$37 per cow. For 100 replacements the total would be \$3700. This does not include any additional value the AI

daughter might have if sold as a replacement.

Because our example is based on only using young AI bulls, the semen cost per service would not be more than \$5. Other AI costs could total as much as \$12 to \$15 per insemination to obtain the \$50 if the cost of the natural service bull is \$12 per service. Given the rates charged by AI technicians, these values are excessive if it costs less than \$5 per cow to check for estrus.

In my opinion this simple example justifies my beginning statement that AI will practically always be more profitable than natural service if replacements are to be saved.

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NOTES

Contract Considerations For Dairy Replacements

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Contract Considerations For Dairy Replacements

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Increasing herd production through improved genetics is the main reason for retaining ownership in herd replacements. Contract rearing of dairy heifers can allow the dairy operator to focus resources on the milking herd while still maintaining a supply of quality replacements of known genetics. Effective agreements (contracts) must be mutually beneficial to the herd owner and replacement grower. These agreements must also consider the basic fundamentals in producing well grown, low cost, correct body condition, ready-to-calve replacements.

Background Discussion

Replacement heifers represent a major expense in producing 100 pounds of milk. For example, replacement expense is second only to feed in most budgets. Therefore, contract rearing agreements must be competitive with home grown cost. In addition, feeding and management of the replacement directly impact first lactation production and herd life production. Agreements and/or conditions of the contract should optimize future production potential of a quality ready-to-calve replacement. Total costs from birth to first calving are also directly impacted by feeding and management. These key relationships hold true in operations where replacements are home grown or when replacements are grown under contract by a second party (grower). Providing adequate sized replacements near the 23-25 month age range at the lowest possible cost should be the objective in both situations. The following discussions will focus on key considerations for contract rearing of replacement heifers.

The summary of cost from birth to first calving (10 days prior) in Tables 1-3 will aid in this discussion of contract considerations. Four time periods are used to discuss replacement heifer feeding, management and expense. These periods consist of the liquid feeding, weaning to 400 pounds, 400 pounds to breeding and breeding to calving. The summary of expenses in Tables 1-3 are based on heifers weighing 1,333 pounds at 25.1 months of age. The liquid feeding period is 60 days with breeding weight set at 850 pounds. Total gain from birth to calving is 1,243 pounds with a 1.62 pound average daily gain. Feed cost is based on alfalfa hay and corn silage blended with grain to meet growth requirements using least cost formulations in each period. Rations were formulated for moderate rates of average daily gains of 1.0 lb liquid feeding period, 1.6 lb weaning to 400 lb, 1.8 lb from 400 lb to breeding and 1.6 lb from breeding to calving. Higher rates of gain tend to increase daily expense and decrease cost for gain, but may lead to fat replacements with subsequent reduction in milk production.

Non-feed costs include yardage, interest on livestock and operating, breeding, death loss and cull loss. Yardage was set at \$.75 per day during the liquid feeding period and \$.25 from weaning to first calving. Yardage includes labor, bedding, required drug and veterinary cost, ownership cost on facilities and equipment and operating cost on equipment. The distribu-

tion of these costs are summarized in Tables 2 and 3. Feed and yardage would be major items transferred to the replacement grower. Breeding and death loss is usually negotiable between the two parties. Depending on the method of payment, interest on operating may or may not be transferred to the grower. The owner of replacements on contract is usually billed monthly for all or partial payment for heifers on feed.

Contract Considerations

The cost summary in Tables 1-3 reflect typical costs from birth to first calving and respective costs for the four time periods. Agreements may be made to transfer replacements to second parties for only segments of the total growing period. These might include birth to weaning or more typically from around 400 pounds to calving. The average daily cost per pound gain differ greatly during the four time periods summarized in Table 1. The liquid feeding period and breeding to calving period have higher costs per day and cost per pound of gain. Typically, the growing periods after weaning to breeding are associated with lower feed cost and more efficient gain.

Liquid Feed Period

The length of the liquid feeding period is a key consideration in contract growing dairy calves. Non-feed expense exceeds feed expense in the example cost summary in Table 1. Labor requirements during the liquid feeding period account for the majority of non-feed expense. This is directly related to the length of the liquid feeding period. Our example is based on 60 days. The impact of liquid feeding period length is illustrated in Table 4 with higher cost associated with longer periods. Substantial increases occur with liquid feeding periods of 90 and 120 days. Death loss is also a consideration when working out contract agreements for growing dairy calves. Major losses can occur during the liquid feeding period. Provisions should be included in agreements to address calf mortality.

Growing Heifers

Starting weight and breeding weight are key considerations on heifer contracts. Heifers are often started on the dairy followed by contract growing. Usually these heifers are in the 400 pound range at the time of transfer. Feed intake increases and efficiency of gain decreases in growing heifers. Consequently, cost per day and cost per lb gain increases with size. The starting weight of contract heifers directly impacts the average cost from beginning to end of the feeding period. This starting weight consideration is illustrated in Table 5. Lighter starting weight calves result in lower daily expense and lower gain cost to breeding (conception) and to calving. This calculated cost advantage with a lighter starting weight has been documented by research feeding trials conducted by the University of Idaho. In these trials a steady increase in cost occurred with increases in starting weight of Holstein heifers.

Increasing the weight at breeding results in a corresponding increase in the weight of the ready-to-calve replacement. Replacement heifers that exceed 1350-1400 lbs prior to calving are usually past 900 lbs at breeding. The impact of two breeding weights (750 lb and 850 lb) are summarized in Table 6 and include cost to conception and calving. Based on 85% heat detection efficiency and 1.5 services per conception most heifers conceive about 25 days after going into breeding groups. The data in Table 6 is based on the assumption that the average daily gain prior to breeding weight remains the same under both situations. This management decision results in only small increases in daily or gain based ration costs. Total feed cost due to an increased num-

ber of days on feed (56 additional days on feed prior to breeding) results in much higher growing cost to the owner of the replacement. Total non-feed cost also increased with increased weight at breeding. Cost comparisons by the University of Idaho suggest that increasing breeding weight by 100 lb adds \$87 to the cost of the replacement heifer.

Discussion

An unlimited number of contract arrangements are being used to compensate the grower for rearing dairy heifers. Feeds, labor, and facilities are usually provided by the grower for a set fee. Death losses, breeding fees, drugs, veterinary services and transportation are often negotiated within general agreements based on gain, daily head charge or feed plus yardage. The bottom line to the replacement owner is “what is it going to cost?”. The cost to the dairy owner will depend on the share of economic responsibility that is transferred to the grower. The following is a brief discussion of possible methods of establishing cost for replacement contracts.

Gain Based Contracts

Many contracts for rearing dairy heifers are based on weight gain. A specified price is established for the total gain of the animal during the contract period. Fees for breeding are often charged directly to the owner. The grower is usually expected to provide lockup breeding pens. Heat detection may be the responsibility of the grower or the AI technician provided by the replacement owner. Upper limits for average daily gains may be set by the replacement owner.

Advantages for contracting on a gain basis include a fixed cost over the contract period and ease of calculations. Changes in feed price over the feeding period will not impact the cost to the replacement owner but, impact the grower. Gain based agreements must take into account differences in the receiving weights of incoming replacements and breeding weight consideration. Some stepwise pricing schemes are being used to compensate for receiving weights. For example, \$.02 increases in contract price for each 50 lb increment over 450 lb. Since the cost per unit gain decreases with higher average daily gains, some conflicts can develop over the degree of conditioning on replacement under gain based contracts. Growers may tend to favor high average daily gains because of favorable economics however, these gains may be detrimental to the replacements and not in the best interest to the owner.

Daily Charges on a Head Basis

Contracts are also being based on a daily charge per head. Daily charge is determined for the feeding period. Receiving and breeding weights require consideration in this arrangement as with gain based contracts. This provides easy monthly billing to the replacement owner and aids in cash flow planning. Rate of gain becomes less important to the grower. The replacement owner in this arrangement will usually specify expected rates of growth or performance. Feed costs per day increase with larger heifers. Likewise starting weight of incoming replacements will impact average daily ration cost to calving to the grower. As with gain based contracts, other expense items are negotiated. Getting replacements bred impacts days on feeding. Consequently, breeding arrangements should be clearly defined.

Feed Plus Yardage

Feed plus yardage is a common method to feed beef cattle on contract. Feeds are charged to the cattle owner with a daily yardage charge of \$.15 to \$.25 assessed per head to cover labor, facilities and grower operating cost. Gain is less important to the grower. Total cost for rearing replacements become more variable to the owner. Risk for major changes in feed price are shifted to the replacement owner. Feed plus yardage reduces any possible conflicts between the grower and replacement owner on rate of gain. Discussions are usually necessary to establish the items covered in the yardage charge (heat detection, veterinary and drugs, death loss etc.).

Ration Cost Only

Rations cost include feeds plus markup to cover labor and other expenses normally considered yardage. Gain is not important to the grower unless minimum levels are set by mutual agreement between the owner and grower. The owner may have input into ration specifications and/or requirements. This method allows for monthly billing, however, exact billing amounts are less predictable. Cost for additional expenses are negotiated.

Option to Purchase

Option to purchase contracts are also used to farm out replacements. The owners sells the calf or started replacement heifer but reserves the right to buy the springer at current or a pre-determined price. The owner may retain a partial interest in each animal that is transferred to the grower if the owner elects not to buy the replacement at the end of the contract. This method transfers all growing costs to the grower (owner) of the replacement. Long term springer heifer price may impact the cost of replacements to the dairymen selecting this method unless a pre-determined sales price is used in the contract.

Summary

Contract rearing of replacement heifers can be good for both parties. It is an excellent way to market high quality roughage by the grower. The length of the liquid feeding period and calf mortality are key considerations for dairy calves. In growing cattle, receiving and breeding weight impact cost per day and lb gain for the time on feed. Conflicts in rate of gain and body condition can occur on gain based contracts. Contracts based on daily head charges and feed plus yardage prevent this possible conflict.

(Note — HCOST: A Dairy Heifer Enterprise Budget Worksheet, was used to generate cost in this manuscript. The program is available from the University of Idaho for \$10.00. Request MCUG-37, Ag Communications, College of Agriculture, University of Idaho, Moscow, Idaho 83843)

<<<< 6 Tables need to be included >>>>

Table 1. Distribution of Replacement Cost by Time Period.*

Period	Feed (\$)			Non-Feed (\$)			Total (\$)		
	Total	/Day	/Lb Gain	Total	/Day	/Lb Gain	Total	/Day	/Lb Gain
Liquid Feeding	55	.91	.91	61	1.00	1.00	115	1.91	1.91
Weaning - 400 lb	77	.49	.31	62	.40	.25	140	.89	.56
400 lb to Breeding	220	.80	.44	128	.47	.26	348	1.27	.70
Breeding to Calving	346	1.26	.79	211	.77	.48	557	2.03	1.27
Total	698	.91	.56	461	.60	.37	1159	1.52	.93

*Based on 60-day liquid feeding period, breeding period starting at 850 lb and calving at 25.1 months and 1333 lb.

Table 2. Distribution of Dairy Replacement Costs

Item	\$/Head	% of total	\$/Day	\$/Lb Gain
Yardage*	221	19.1	.29	.18
Breeding	27	2.3	.04	.02
Feed Cost	698	60.2	.91	.56
Death Loss	37	3.2	.05	.03
Cull Loss	12	1.1	.02	.01
Interest Operating	61	5.3	.08	.05
Interest Livestock	102	8.8	.13	.08
total	\$1,159	100%	\$1.52	\$.93

*Yardage based on \$.75/day liquid feeding period and \$.25/day all other periods.

Table 3. Percent Distribution of Cost by Time Period

Item	% of Period Cost				
	Liquid Feeding	Weaning to 400 lb	400 to Breeding	Breeding to Calving	Total Time
Yardage and breeding	39.2	28.1	19.7	17.1	21.4
Death Loss	9.9	6.7	1.8	1.8	3.2
Feed Cost	47.7	55.4	63.1	62.1	60.1
Int. Op. Capital	1.4	3.6	6.2	5.9	5.3
Int. Livestock	1.8	6.2	9.2	10.8	8.9
Cull Loss				2.2	1.1

Table 4. Days on Liquid Feed on Cost to 400 Pounds*

Period	Feed (\$)			Non-Feed (\$)			Total (\$)		
	Total	/Day	/Lb Gain	Total	/Day	/Lb Gain	Total	/Day	/Lb Gain
60	131	.61	.43	122	.56	.39	254	1.18	.82
90	143	.67	.46	136	.63	.44	279	1.29	.90
120	149	.74	.48	148	.73	.48	297	1.48	.96

* Based on average daily gains for the three liquid feeding periods of 1.0, 1.25 and 1.5 lb respectively.

Table 5. Starting Weight of Contract Replacements on Feed Cost to Calving

Starting Weight	Cost to Conception ¹ (\$)			Cost to Calving ² (\$)		
	Total	Ration/Day	/Lb Gain	Total	Ration/Day	/Lb Gain
350	230	.76	.42	576	1.00	.59
400	211	.77	.43	577	1.02	.60
450	193	.78	.44	539	1.03	.61
500	172	.79	.44	518	1.05	.62
550	153	.80	.45	499	1.07	.64
600	132	.81	.45	478	1.09	.65

¹ Breeding period starting at 850 lb with average conception occurring at 894 lb.

² Values based on total from starting weights to 1333 lb at 25.1 months of age.

Table 6. Breeding Weight of Contract Replacements on Feed Cost to Calving.

Breeding Weight	Cost to Conception ¹ (\$)			Cost to Calving ² (\$)		
	Total	Ration/Day	/Lb Gain	Total	Ration/Day	/Lb Gain
750	174	.80	.44	496	1.01	.60
850	220	.80	.44	566	1.03	.61

¹ Breeding period starting at 750 lb with average conception at 794 lb and 850 lb breeding period with average conception at 894 lb.

² Cost to calving from 400 lb on final weight of 1233 lb for 750 lb breeding (833 lb gain) and 1333 lb for 850 lb breeding (933 lb gain).

56 additional days on feed are required with increased weight at breeding.

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Minimizing Stressors In The Calf's Physical Environment

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What is Stress?

Everyone knows what stress is, however, it is not easily defined. One definition defines stress as adverse effects in the environment or management system which force changes in an animal's physiology or behavior to avoid physiological malfunctioning and assists the animal in coping with its environment. Animals respond to challenges in their immediate environment by several interacting mechanisms including physiological, biochemical, immunological, anatomical and behavioral. Identifying and minimizing stressful situations allows for greater well-being, growth, reproductive efficiency of the animal as well as economic benefits for the producer and consumer.

Common Types Of Stressors

A satisfactory environment for a calf provides for thermal comfort, physical comfort, minimal disease or maximum health, and behavioral needs. Each of these four areas can be a potential source of stress for the dairy calf.

Thermal stress

Cold or heat stress can affect younger or sick animals much more severely than mature, healthy cattle. Thermal comfort may be quantified as the thermal neutral zone. In the calf, the range is 50o to 85oF in still air. This optimal thermal environment promotes maximum performance and provides the least stress for the calf. Within this thermal neutral zone, the calf can maintain body temperature, or homeothermy, by constriction or dilation of the blood vessels, changing postures or behavior, changes in hair, or by sweating and panting. As air temperature falls below 50oF, known as the lower critical temperature, the calf must divert food energy from production or growth to produce additional metabolic heat and maintain body temperature. This ultimately leads to a reduced feed efficiency. Cold stress has also been shown to decrease the rate of absorption of colostrum in newborn calves.

The upper critical temperature, approximately 85oF, is reached when the calf cannot dissipate enough metabolic heat to the environment to maintain homeothermy. Thus food intake is reduced, thereby lowering heat production generated by digestion and absorption of nutrients. This decreases the growth rate in calves. Other environmental factors such as humidity, wind-chill factors, and moisture due to rain or mud, affect the upper and lower critical temperature of the environment.

Environmental

The physical component of the calf's environment includes the space available and the surfaces with which the animal comes into contact with. Flooring materials and space allocation in confinement systems have been studied in calf systems. In a recent University of

California, Davis study of commercial veal facilities, the size of the individual stall and the practice of tethering calves was studied for stress effects based on both physiological and behavioral data. Individual stalls ranging in width between 18-22 inches were found adequate for calves weighing between 350-400 pounds. The practice of tethering calves to the front of individual stalls was not stressful to the calves as measured by growth rates, cortisol levels, and white blood cell types.

Another environmental stressor of the calf's environment which may have a greater impact on health and well-being is the waste management system. Toxic gases, especially elevated ammonia levels, can cause damage to the lung epithelium and precipitate respiratory disease. The calf may be continually exposed to these gases with the accumulation of manure and urine.

Calves placed in group pens should be provided with enough feeder space to allow all calves access. Water availability should also provide easy access, especially to the small, young calf. Slippery surfaces should be avoided to prevent injury, both in individual stalls and group pens.

Disease

This stressor is that which results in the onset and spread of disease. The susceptibility of the calf depends on many factors including its immunity levels, pathogen challenge and preventative health program. The newborn calf is dependent on colostrum for the first 30 days of immunity. Greater mortality, increased morbidity, and lesser weight gains have been correlated to the ingestion of colostrum. The calf must receive the colostrum within 24 hours, and preferably within 6 hours to maximize the transfer of passive immunity. Colostrum not only contains necessary immunoglobulins, but also contains higher concentrations of protein, fat, vitamins and minerals than compared to milk of later lactation. Thus, colostrum assists the newborn calf both in immunity and enhanced nutrition.

Cleanliness and stocking density can affect the pathogen challenge to the calf. Dry, sanitized, and clean housing is important in minimizing disease. The umbilical cord should be dipped in 7% tincture iodine solution to help prevent access to pathogenic bacteria. Vaccination and parasite programs are important components in effectively managing disease and parasitic infections. Herd history and age of calves will assist in planning an effective preventative health program.

Other Stressors

There are numerous other examples of common stressors in the management of dairy calves. These include management techniques such as ear tagging, dehorning, or transportation. These management techniques should be planned to minimize the total additive effect of all stressors on the calf. Social stress can occur when calves are isolated from herd mates or through interaction of an individual herd mates. Calves recently introduced to a herd, and sick or injured calves may experience social stress.

One stressor which is easily eliminated is the improper handling of calves by caretakers which can cause both behavioral and physiological stress effects.

Effects Of Stress

The reaction of the animal to stressors depends on the duration and intensity of the stressors, the animal's previous experience to the stressors, its physiological status, and the immediate environmental restraints. An animal may react either by a behavioral or a physiologi-

cal response, but most often a combination of both. The duration and intensity of stress can impact the animal's capacity to grow, reproduce and maintain health.

A normal behavioral response to an immediate and acute type of stress is easily observed. The calf usually will exhibit a fleeing response, if the environment allows it, or the calf is not restrained. An example of this type of stressor is a loud noise or a short term, painful procedure, such as administering injections.

Some abnormal behavioral responses have been categorized as "stereotypies". Stereotypies are sequences of movements which are repeated over and over without any apparent function. Examples of stereotypical activities in calves are tongue rolling, head butting, and repetitive licking and/or scraping of objects. Stressors which induce stereotypic behaviors can be situations in which calves are isolated from herd mates for extended periods of time or deficiencies in feeding programs.

Physiological responses to stress have been investigated more than behavioral profiles. However, no one physiological parameter has been identified to quantify a stress response. In both humans and animals, parameters which have been utilized in studying the stress response include measuring levels of hormones released from the brain and other organs, fluctuations in white blood cell parameters, and changes in the heart rate. A short term stressor, such as a loud noise, increases the heart rates and may cause constriction of the blood vessels. A stressor which lasts several seconds to a minute may increase heart rate, respiration rate, and cause digestive upset or decrease feed intake.

A long term, chronic stress, usually 24 to 48 hours, can occur in calves which are shipped or experience thermal discomfort. This longer term stress influences a number of systems in the animal including the immune, digestive, and reproductive systems. Long term stress can influence hormones essential in reproduction, growth, energy metabolism, and response to disease or infection. These deficiencies can continue after the stimulus from stressor has been diminished or eliminated.

Measuring Stress

The quantification of a stress response by scientists often has been designed to examine only the behavioral or the physiological responses. However, recent data has been collected utilizing a multidisciplinary approach which combines both the behavioral and physiological responses. Behavioral responses to chronic or long term stress can be very difficult to observe. This may be seen in a calf by a decrease in the amount of time spent in a recumbent position, less interaction between herd mates, or less time spent eating or drinking. All of these behavioral responses can manifest a physiological effect by a decreased growth rate and possibly a compromised immune system. Utilization of video recordings has assisted scientists in collecting behavioral data without disturbing the calves by the presence of the researcher. The very basic postures and activities can then be recorded and analyzed for duration and frequency. Thus, calves in different environments are compared and a behavioral profile established for that specific environment.

Physiological measurements of stress are dependent on the interaction of many systems. Some stress responses can be measured by the functionality of the primary system involved. Examples include a high environmental temperature which would increase respiration rate, induce sweating and raise body temperature. Lack of colostrum would compromise the immune system in the calf less than a month old. Changes in hormones such as cortisol, or the reproductive hormones are utilized in quantifying the response to stress. One indicator

of the impact of stress on the immune system is characterized by the ratio of neutrophils to lymphocytes, which are types of white blood cells. Heart rates can be recorded by telemetric systems to monitor the stress response of the cardiovascular system. Stress is important to the dairy producer, since the longer term effects influences the ability of the calf to mature and reproduce.

Minimizing Stress

The first step to minimizing stress on the production facility is to be able to identify the signs and symptoms of stress in both the individual animal and as a herd. This will include observations on appropriate or abnormal behavior, indicators of sickness, and decreased weight gains and subsequent growth. Once a stressor is identified, its rapid elimination will assist in termination of the stress response. Proper management of the calf including housing, waste management, sanitation, preventative health programs, nutrition are essential in minimizing stress. The proper handling of calves, prevention of accidents, and suitable facility design which incorporates the calf's well-being may have a continual effect on behavior as the calf matures to a lactating cow.

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Nutrient Utilization And Cropping

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Nutrient Utilization And Cropping

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Introduction

There have been three significant factors in the last 50 years that have shaped the way we view and manage manure nutrients. The first of these was the development of the technology to make cheap nitrogen. This was associated with the war effort and drastically changed the way we carefully saved and utilized manure. For the first time, manure was thought of as a low value waste produce.

After that development livestock producers managed (or mismanaged) manure as a worthless byproduct for about 15 years. Then in the 1960s, society raised her hand and said 'enough'. Degraded surface water that was unsightly, produced odors, killed fish, and threatened public health in drinking water all led to reforms in manure management practices to protect surface waters. Feedlots were no longer allowed to locate on and dump their wastes into the nearest stream. Producers were again encouraged to spread their manure back on the cropland that produced the feed for the herd. This concern translated into support for research and Extension efforts to do a better job. Concrete slats were developed to reduce the labor needed to collect manure. Equipment manufacturers developed new pumps that could agitate and move thick slurries and apply them to fields through big guns. Taking a page from the handling of human waste, hydraulic or flush systems reduced the time spent scraping manure. Mechanical separators were developed to remove solids, providing a bedding material and reducing the clogging/plugging problems in liquid handling systems. As these new labor saving components in manure handling were developed, herd sizes grew in response to the market.

These new larger dairies and other livestock units, many of them generating great volumes of manure and wastewater, posed a new problem. Taking a page from other segments of American business, livestock producers began to specialize. They were in the business to produce milk. Feed could be contracted for from other agricultural specialists. More cows were gathered on smaller land areas. As a result, groundwater was threatened. In the 1980s, effort was directed to looking at nutrient management as one means of reducing the threat to groundwater sources. Certainly livestock producers were not alone as the widespread use of cheap and effective agricultural chemicals were mismanaged throughout the many phases of production agriculture. In some areas we may still be doing that, but we have learned many things.

Nutrients Generated

As animals have gotten bigger and feed rations have improved, the characteristic of the manure and wastewater has changed. Most values are shown as a single number when in fact any value

represents a range. These values will vary by season, ration, stage of lactation, climate and management system. Recent values published in the 1991 SCS Agricultural Waste Management Field Handbook serve as an excellent reference source. Values reported from that source on as "excreted" manure in lb/day per 1000 lbs of animal waste are shown in Table 1.

Table 1: Nutrients generated by various dairy animals.

	Nutrients for Dairy Animals (lbs/day/1000# live weight)		
	Lactating Cows	Dry Cows	Heifers
N	0.45	0.36	0.31
P	0.07	0.05	0.04
K	0.26	0.23	0.24

These values do not include bedding or waste water from the milking parlor, but do include a fraction to account for spilled feed.

Nutrient Losses

Determining the amount of nutrients produced and passed by an animal in the urine and feces by a given cow is relatively easy. Following that through the system to land application is a bit more difficult. In an attempt to make some scientific guesses about the pathways and fate of nutrients, we need to know the form of the original nutrient.

About one half of the nitrogen passed by a dairy animal is in the urine, with the remaining half in the feces. Most of that fraction in the urine is in the ammonia form and most of the nitrogen in the feces is in the organic form. Over 80% of the phosphorus in manure is in the feces, while about 80% of the potassium is in the urine. This information is very helpful when evaluating losses of nutrients through various manure management components. For example, most of the potassium will be lost in an open lot system when the manure is scraped up at infrequent intervals. That is the potassium in the urine will not be collected and managed with the solids. A solid separator would allow a dairy operator to remove and haul off-farm a majority of the phosphorus (in the solids) if that were a nutrient that was being applied in excess of crop utilization.

System variation is large, but the table below is included to allow you to place in perspective the magnitude of nutrient losses you might experience with each of the following manure management systems.

Table 2. Percentage of original nutrient content of dairy manure retained by various storage systems.

Method	N	P	K
Daily spreading	80	90	90
Dry (with roof)	70	90	90

Earthen storage	55	60	70
Lagoon/flush	30	40	60
Open lot	60	70	65
Pits (slats)	75	95	95
Scrape/storage tank	70	90	0
None (grazing) — 100% of nutrients retained			

By reviewing Table 2 you can see which management component might be selected to assist a producer who wishes to conserve or lose nutrients from the manure management system.

After the losses occur in the storage/treatment component, there are additional losses during the application of manure/wastewater to the field. Some values of application losses are shown in Table 3.

Table 3: Percentage of original manure nutrient content delivered to cropland and available for plant uptake (these figures reflect application and preutilization losses).

Application method	%N	%P	%K
Injection	95	100	100
Broadcast	80	100	100
Broadcast w/immed. cultivation	95	100	100
Sprinkling	75	100	100
Grazing	85	100	100

This discussion has moved quickly through some of the losses that occur between the cow and the field. While quite variable, this will allow you to calculate the strength of the nutrients that you are about to land apply. The best value would come from a representative sample of the material that will be spread on the field. Concern about ground water pollution has lead most state agencies to talk about application of manures at the agronomic rate. This means that you should be allowed to (or limited to) put on the field about what is taken off in the crop. As one goes to the field to land apply your manure/wastewater, how do you determine the application rate?

There is a good database on the nutrient content of the harvested crop for most of the crops grown. An example of some of these are shown in Table 4.

Table 4: Rates of nutrients used by various crops.

Crop	Unit	Rate (lb)	Rate (lb)	Rate (lb)
		N	P	K
Alfalfa, immature & early bloom	per ton	65.0	5.3	42.0
Alfalfa hay, midbloom to mature	per ton	45.0	4.54	36.0
Canarygrass hay	per ton	40.0	7.3	63.0
Orchardgrass	per ton	38.4	6.1	37.6
Cereal grain hay	per ton	24.0	3.4	10.0
Grass hay	per ton	25.0	3.6	19.4
Barley/oats	per ton	4.0	5.0	7.2

Crop	Unit	Rate (lb)	Rate (lb)	Rate (lb)
		N	P	K
Alfalfa/grass silage	per ton/wet	22.0	2.9	9.0
Red clover silage	per ton/wet	14.5	2.0	12.0
Corn silage	per ton/wet	7.0	2.5	6.6
Corn earlage	per ton/wet	25.5	4.6	5.6
Grazed grass (by region, range indicated)	per acre	50-165	19-24	87-110
Harvested grass (by region, range indicated)	per acre	80-220	2-28	92-132

However, we know nutrients do not only go into the crop. The problem begins when we evaluate the very complex question of where the nutrients go in field applied manure. Let us follow nitrogen as it has six pathways of movement. Phosphorus and potassium are limited to 4, since they cannot be lost as a gas. The six pathways for nitrogen are: volatilization as ammonia into the atmosphere, loss as nitrogen gas from denitrification, move with surface water in runoff, lost below the root zone in leaching, taken up by the crop and added to the reservoir of nitrogen in the soil organic matter.

As you would expect, the amount of nitrogen that goes into each of the pathways will vary with a wide variety of conditions. Volatilization losses will be influenced by the form of the nitrogen (% as ammonia) in the manure/wastewater. For example, if the manure management system did not collect, or the system has already lost the ammonia in the urine, then the volatilization losses will be reduced. Usually as the manure application rate goes up, the amount of ammonia lost will go up. However, the percent of the total amount of nitrogen lost through this pathway will decrease.

Denitrification, a biological process, will be influenced by the soil type and moisture content as they change saturated conditions and available oxygen supplies. Small micro-sites of anaerobic conditions are required to promote the conversion of nitrate (NO₃) to nitrogen gas. Research reports suggest from 2-50% of the nitrogen may be lost through this mechanism. The climate (rainfall frequency, intensity and duration) are very important in calculating expected losses of nitrogen in surface runoff or deep leaching. Soil permeability, slope and ground cover, is also very influential in effecting water movement. The amount of nitrogen that will be added to or taken from the soil reservoir are influenced by climate and a host of soil properties, such as organic matter content, pH, etc. The above examples are listed to show that amount of nitrogen that goes into each pathway varies considerably.

One of the most influential factors in determining the percent in each pathways is the application rate. With small annual application, one would expect crop uptake to utilize a high percentage of the crop. With increased application the amounts over crop uptake will move in other pathways. Should it rain the day after spreading, the amount going with runoff would be expected to increase. As you can imagine the list of variables are quite large and the serious reader is encouraged to refer to other more complete research reports for a complete coverage of this topic.

Nitrogen Losses From Research Study

However, to provide a prospective of possible nitrogen movement, the data below is shared from a research study conducted at three sites in Oregon. Dairy manure was put on pasture (rye-grass-orchard grass) in several applications through the two-year study. The above mentioned six pathways were monitored throughout the study. One site was on the Oregon Coast (92"/yr rainfall) in a silt loam soil. Sites two and three were close together in the Willamette Valley (42"/yr

rainfall) and the soil types were a silty clay loam (poorly drained) and a heavy silt loam. At all three sites manure was applied on triplated plots at target rates of 0, 150, 300 and 450 pounds of nitrogen per acre per year.

For details of the monitoring techniques, the reader is referred to the paper on the pathways of nitrogen movement from land spread manures, cited in the references.

The summary of the data is shown in Table 5. While there is much data contained in this table, a complete review and discussion is not possible. However some important items for your consideration include:

1. There is still crop production and other forms of nitrogen movement in all plots, even through the control plots received no manure. This nitrogen comes from the tremendous reserve built up in most agricultural soils.

2. The percent of nitrogen that goes into the crop decreased as application increased. The range was from 120-30% of applied. The 120% occurred because the plants took nitrogen from the existing soil bank in addition to the applied manure.

3. Volatilization losses occur with essentially every manure application. The amount is independent of crop and soil type. It is influenced by application rate, number of applications and amount of ammonia in the applied manure. In these studies manure was applied up to 7 times on one set of plots, which is perhaps more applications than is typical on one piece of ground. The manure was fresh; scraped from a flush alley so it contained some, but not all of the ammonia in the urine. The percent of nitrogen lost to volatilization ranged from 20-27%, the lower percentages coming from the higher application rates.

4. The producer has almost no control over denitrification losses. As stated they are influenced by soil type and moisture content primarily. In this study they ranged from 28-9% of the total nitrogen applied. This was still over 100 lbs of nitrogen per acre on the Quillamook high rate plots.

5. Given the rainfall rates of the areas, the losses with surface and deep leaching water was surprisingly small. Other combinations of soil permeability, spreading/rainfall events and climate could change the values significantly. These are the two forms of loss that provide the greatest pollution potential and concern.

6. The soil reservoir is very large and very influential in studies such as these. In one set of plots over 180 lbs of nitrogen was taken from the existing soil system while in another set of plots over 100 lbs. was returned to the system. In this study the additions in added manure nitrogen was about 5% of the nitrogen that existed in the soil profile.

Conclusions

Manure management systems must recognize all the nitrogen (and other nutrients) losses that occur in the system. Estimates or measurements, where possible, should be made of the fate of all applied nutrients. Sampling and analysis of manure before it is spread can provide the producer a good idea of the concentration of the nutrients going onto the field.

Most certainly the application should be made in recognition of the uptake potential of the crop/crops grown on the site. Particular concern should be given to the movement of nutrients in water from the site, either overland or down through the profile. These are the losses that are of greatest concern today.

Losses as ammonia through volatilization is a concern, but today in the U.S. it is of less importance than the pollution potential moving with water. Losses of nitrogen through denitrification as nitrogen gas poses no threat to our environment.

How much above agronomic rate can we apply manure? The answer is not clear. We know the processes that are involved and have a fair understanding of the factors which influence the rate of movement through the pathways. What happens to the manure application in the field in section 2, range 5, planted to sorghum on August 14 in North Texas or the pasture in Western Washington, just south of Seattle on February 1, is almost unpredictable each year with any degree of confidence.

This makes it difficult for producers and regulators alike. Although we are all going to the same goal, there is considerable room for discussion. Hopefully some of the above factors will provide you with a better understanding of the possible variations.

Table 5. Nitrogen in each of the pathways in kg/ha (lb/ac) per year and as a percentage of actual nitrogen applied in 1991.

Quillamook	0		152		304		456	
	#/ac	%	#/ac	%	#/ac	%	#/ac	%
Crop uptake	157	86	183	120	220	72	213	47
Volatilization	0	0	35	23	65	21	90	20
Denitrification	12	7	38	25	58	19	108	24
Runoff	8	4	8	5	11	4	14	3
Soil water	5	3	7	5	17	6	25	5
Soil nitrogen	-182	-100	-119	-78	-67	-22	6	1
Total	0	0	152	100	304	100	456	100
Amity	0		129		258		387	
Crop uptake	132	78	157	122	161	62	196	51
Volatilization	0	0	35	27	65	25	90	23
Denitrification	21	12	36	28	44	17	47	10
Runoff	10	6	12	9	16	6	18	4
Soil water	6	4	8	6	14	5	20	4
Soil nitrogen	-169	-100	-119	-92	-42	16	16	4
Total	0	0	129	100	258	100	387	100
Waldo	0		129		258		387	
Crop uptake	46	60	76	59	92	36	115	30
Volatilization	0	0	35	27	65	25	90	23
Denitrification	11	14	24	19	31	12	33	9
Runoff	14	18	16	12	18	7	20	5
Soil water	6	8	7	5	12	5	17	4
Soil nitrogen	-77	-100	-29	-22	40	15	112	29
Totals	0	0	129	100	258	100	387	100

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1993 WESTERN LARGE HERD MANAGEMENT CONFERENCE
NOTES

Free-Trade Agreements: Effect On The U.S. Dairy Industry

James P. (Tom) Camerlo, Jr.,
President National Milk Producers Federation

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Free-Trade Agreements: Effect On The U.S. Dairy Industry

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International trade is one of the hot topics in dairy circles these days. Look at the record of key dairy issues at the national level last year. First it was humanitarian assistance to the former Soviet Union, under which over \$100 million worth of U.S. dairy products were shipped to the former Soviet republics last winter. During the spring, U.S. dairy interests successfully opposed increased imports of Goya cheese under the Generalized System of Preferences (GSP) program and stopped domestic price undercutting by imported Swiss cheese. Summer saw the conclusion of negotiations for a North American Free Trade Agreement (NAFTA), which would progressively open up trade in dairy products between the U.S. and Mexico.

By last fall, commercial exports of U.S. dairy products under the Dairy Export Incentive Program (DEIP) began to reach levels that attracted widespread attention. Under the DEIP, contracts to commercially export about 2.65 billion pounds (milk equivalent) of U.S. dairy products were signed during 1992. By winter, an agreement on agriculture reached between the U.S. and the European Community (EC) seemed to pave the way to wrap up the 6-year-old Uruguay Round multilateral trade negotiations under the General Agreement on Tariffs and Trade (GATT). While the GATT negotiations are not moving as fast as was thought late last year, nevertheless an eventual GATT deal would bring further changes to the U.S. dairy industry, both in terms of additional imports as well as additional export opportunities.

Involving such things as DEIP, GATT, NAFTA, GSP, GSM, and the EC, this may all appear more like alphabet soup than serious matters U.S. dairy farmers should pay attention to. But international trade has come to the U.S. dairy industry to stay, and it will have an increasing impact on all our bottom lines.

In my comments, I want to focus on free trade agreements, such as NAFTA and the Uruguay Round negotiations under GATT. How will they fit into this overall picture of a greater international orientation for the U.S. dairy industry? How will they effect the industry?

Background

The United States possesses one of the world's largest and most productive dairy industries. In comparison with the dairy industries of other countries, particularly industrially developed countries, the U.S. dairy industry ranks at or close to the top by such measures as total milk production and productivity per cow. In 1991, 148.5 billion pounds of cows' milk was produced in the U.S., more than was produced in any other single country. The U.S. ranks second in total production behind the 12 countries of the European Community (EC), which maintains a common agricultural policy with respect to manufactured dairy products and international dairy trade. During 1991, 240.4 billion pounds of milk were produced in the EC. Furthermore, the U.S. would rank in third place in terms of milk production in the world overall if the 15 republics of the former Soviet Union, which collectively produced 223.2 billion pounds of milk in 1991, were counted together.

By various measures of efficiency of milk production, the U.S. also ranks at or close to the top. The average cow in the U.S. produced 14,868 pounds of milk during 1991, which was the second highest national average milk cow yield in the world. Only the small and highly intensive dairy industry in Japan showed a higher average per cow yield in 1991, at 16,843 pounds per cow. Furthermore, in terms of such measures as cost per unit of milk production, the U.S. ranks lower than all but a handful of countries with pasture-based dairy industries.

Given the size and efficiency of the dairy industry in the United States, it is particularly remarkable that our industry ranks very modestly in terms of the role that international trade plays in the industry overall at this point in time. In terms of exports, ours is an industry whose marketing focus, with a few exceptions, has been confined almost exclusively to the domestic commercial market.

For example, of all the major internationally-traded dairy products, cheese is by far the most important in the domestic dairy economy. Over half of the U.S. milk supply used for manufactured dairy products is used to make cheese, and almost a third of total U.S. milk production is used for this purpose. Yet the U.S. accounts for scarcely one percent of the world's cheese exports. During 1991, the U.S. exported less cheese than the European Community, New Zealand, Australia, Switzerland, Austria, Finland, Norway, Bulgaria and Hungary, countries which are either much smaller producers than the U.S., or higher cost producers, or both. The U.S. ranks far below all developed countries, with the exception of Japan and South Africa, in the proportion of its domestic cheese production that it exports.

Though somewhat less dramatically, this pattern repeats itself for butter and most other dairy products. Only for whey, lactose, ice cream and, in certain years, milk powder have U.S. exports represented a significant proportion of either world trade or U.S. production volumes.

There are several reasons why the U.S. historically has not been a major player in international dairy markets. The domestic market has generally experienced sufficient growth to absorb most of the additional milk production generated by rising productivity. In addition, since most developed countries are at least self-sufficient in dairy production, demand for internationally traded dairy products has been largely confined to developing countries with limited financial resources to support their demand.

Most importantly, over the past two or three decades, Western and Northern European governments have aggressively supported their domestic dairy sectors through a combination of high price supports and large-scale export subsidization of the resulting surplus production of milk and dairy products. The United States, following a less aggressive policy of support and export subsidization, has faced entrenched competition and unattractive prices when it looked for dairy marketing opportunities beyond its borders. The U.S. export track record during this time consisted almost exclusively of low-price government sales of dairy commodities acquired in the course of domestic price support operations. International Dairy Trade Outlook for the U.S.

In the late 1980's, this picture began to change. The European Community, by far the world's largest subsidizing dairy exporter, imposed production controls on its dairy sector. While still operating at a substantial surplus, the EC dairy industry is expected, through a combination of budget pressures and policy reform, to be brought steadily, if slowly, into a position of greater supply-demand balance. This will come about through a combination of EC budgetary difficulties and internal political pressure to reform the Community's agricultural support programs. This has, and will continue to, result in a gradual reduction of world stocks of dairy products, cutbacks in subsidized export volumes and slowly rising world prices.

The market situation facing the U.S. dairy industry is also changing on the demand side, both domestically and internationally. In the U.S., the market for food is mature, with an outlook for little overall demand growth. Population growth, a primary engine of growth in dairy product consumption, is expected to slow from the present 1.0% annual rate to half this level in the next decade. The population is ageing and becoming more ethnically diverse, which will likely cause domestic per capita consumption of dairy products to decline from recent levels. These population changes, combined with projections of slow growth in domestic food expenditures and with other factors, points to only modest growth, if any, in domestic consumption of dairy products. The domestic market, therefore, will be unable to absorb increased production stemming from an ever-rising level of productivity in the U.S. milk production sector in the future.

On the international side of the demand picture, the situation is evolving in quite a different direction. The economies of many countries in Latin America and Asia are undergoing rapid development, resulting in rapid growth in per capita incomes. This income growth and the spreading westernization of diets is fueling rapidly rising demand for high-quality food products, including dairy products.

An excellent illustration of the importance of the dietary changes sweeping the rest of the world, and their potential impact on our industry, can be found in a recent newspaper report on the growth patterns of the Japanese people. This article reported that, over the past 30 years, the height of the average Japanese male has increased nearly 4 inches, while average female height has gone up almost 3 inches. Interviewed as to the reason for this remarkable change, the director of nutrition for Japan's health ministry responded, "the chief reason for the increase in body size is almost certainly diet. The dominant pattern of Japanese dietary change since World War II has been westernization. Grains, particularly rice, have declined in importance, and the caloric intake from animal foods has increased sharply. Meat and dairy consumption has gone way up." This official concluded on a very interesting note by remarking that, "this is one of the mysteries of Japan. Once we decide to do something, all over the country, everybody does it."

Japan is just one Asian country, which happens to be further along the path of economic development than others. Projected to the billions of people in all of Asia, Japan's experience points to a very large potential rate of growth in international demand for dairy products. Furthermore, none of these countries is self-sufficient in milk production now, and most are even less likely to be able to expand domestic production of milk and dairy products to meet expected increased future demand.

Given these changes, exporters and buyers are increasingly looking to the United States to become a significant export supplier of dairy products in the future. This country certainly has the long-term capacity to play such a role in the international dairy economy. Only five countries with established, export-oriented dairy industries appear to have clear-cut cost advantages over the U.S. — New Zealand, Australia, Argentina, Uruguay, and Ireland. In all five, which collectively produce little more than one-third as much milk as the U.S., the domestic milk production systems are predominantly pasture-based. Such systems result in low cost milk production but they are generally unsuited to expansion of production unless additional pasture land or supplies of feed can be developed or bid away from alternative uses at low cost. Argentina would appear to be the only country with the potential to do so.

International Trade Agreements

International trade agreements are likely to play an important role in this evolving international trade picture for the U.S. dairy industry. Of greatest interest, of course, is the eventual resolution of the Uruguay Round multilateral trade negotiations under the General Agreement on Tariffs and Trade (GATT), still uncompleted after six years of negotiations, and the North American Free Trade Agreement (NAFTA), which has been signed but awaits congressional ratification.

Both of these agreements, as well other potential agreements in the future, will impact the U.S. dairy industry in several very broad ways. First of all, they will change the conditions of market access in the U.S. and in other countries subject to the agreements. The conditions of market access mean the extent to which, and the terms under which, domestic dairy markets are open to imports from other countries.

In the U.S., imports of most dairy products are restricted under quotas imposed under the authority of Section 22 of the Agricultural Adjustment Act. U.S. dairy import quotas amount to about 4.3 percent of domestic consumption of cheese, 2.3 percent of domestic consumption of non-fat milk solids and 1.1 percent of domestic consumption of milkfat. Other countries employ similar import control systems. In the European Community and other European countries the mechanism is a variable import levy or tariff. In Canada, Mexico, Japan and certain other countries, it's an import control or licensing system. The U.S. and other countries also impose ordinary tariffs on dairy product imports.

International trade agreements would also affect the use of export subsidies, which are currently one of the major factors causing distortions in world dairy markets.

The following is a brief description of the changes that NAFTA and a potential Uruguay Round agreement under the GATT would cause from the perspective of our industry in terms of market access, export subsidies and other matters.

NAFTA

Under the NAFTA, Mexico would relinquish its current import licensing requirement for various U.S.-origin dairy products, replace it with ordinary tariffs in the case of cheese and evaporated milk and with an initial 40,000-ton duty-free quota for nonfat dry milk, and phase out all tariffs on dairy products imported from the U.S. over 10 years (15 years for the over-quota tariff on nonfat dry milk).

Since Mexico is one of the world's major dairy-importing nations, this additional, preferential access for the U.S. dairy industry to that country's markets would represent the major positive feature of the NAFTA for our industry.

On the other hand, the U.S. would also grant Mexico duty-free quotas on all dairy products currently subject to U.S. import quotas under Section 22. These quota levels for Mexico would start out at a level equal to 5 percent of the current Section 22 quota quantities for all countries, and be expanded at a compounded rate of 3 percent per year. Furthermore, these quotas for U.S. imports from Mexico would themselves be converted to into "tariff-rate quotas," under which imports would be permitted above the quota levels but would be subject to specified, and initially prohibitive, "over-quota" tariffs. These over-quota tariffs, as well as certain ordinary tariffs on dairy imports, would be entirely phased out over 10 years.

Therefore, as far as tariff and quota restrictions are concerned, dairy trade between the U.S. and Mexico would be almost entirely free of restrictions ten years after the implementation of NAFTA.

Although it is one of the three signatory countries to the NAFTA, Canada did not agree to make any market access concessions in the NAFTA negotiations as far as dairy products are concerned. Thus, the only NAFTA provisions that relate to market access in dairy products are those that will affect bilateral dairy trade between the U.S. and Mexico.

An important NAFTA provision affecting market access involves so-called “rules of origin.” Rules of origin refer to the specific provisions in a trade agreement that determine whether a product produced with the use of imported ingredients or components is considered, for customs purposes, to originate in the country where it was produced, as opposed to the country in which the imported ingredients or components were produced.

The National Milk Producers Federation was able to secure rules of origin in the NAFTA that would largely prevent dairy components that originate in the EC, New Zealand and other countries, including Canada, from being incorporated into products considered to be of Mexican origin. These special dairy rules of origin will not apply to a few products that are currently under Section 22 dairy import quotas nor to certain other Section 22 products if their dairy composition is below certain specified amounts. Furthermore, the rules cannot prevent Mexico from replacing the dairy products it exports to the U.S. under the NAFTA market access agreement with cheaper, subsidized imports from the European Community and other countries. And, as is true of many other provisions, the NAFTA rules of origin for dairy products will not benefit the U.S. dairy industry unless they are strictly enforced. However, overall, the NAFTA rules of origin on dairy products are very tight and should prevent any economically significant circumvention of Section 22 quotas applied to countries other than Mexico.

One of the most important factors that will determine how the NAFTA would affect the U.S. dairy industry is the fact that international dairy markets are heavily distorted through the practice of export subsidization by the EC and other, primarily European, countries. Because of this situation, export subsidies will be required to make many U.S.-produced dairy products competitive in the Mexican market, even though the NAFTA will grant the U.S. certain preferential access to that market.

While the NAFTA provisions on export subsidies do not prohibit U.S. export subsidies on exports to Mexico, this basic economic fact means that the U.S. dairy industry will not automatically be able to realize all potential gains from the NAFTA market access agreement. In fact, it would not be too far-fetched to state that one of the most important factors that would ultimately determine how valuable NAFTA will be for the U.S. dairy industry is the degree to which dairy export subsidies continue to be employed in world trade by non-NAFTA countries. The NAFTA does provide that the U.S. may request consultations to urge Mexico to take action to counter the effect of subsidies used by the European Community and other countries to export dairy products to Mexico. However, it remains to be determined how this provision will apply in practical terms.

The NAFTA also includes provisions relating to the sanitary and phytosanitary standards maintained by individual countries. These provisions essentially require the health-related sanitary and phytosanitary standards maintained with respect to trade between the three NAFTA countries to: 1) be based on scientific evidence, 2) not be applied in an arbitrary or discriminatory manner, 3) be developed based on the principle of risk assessment, and 4) be applied only to the extent necessary to achieve a clearly understood level of protection.

A country would be in conformity with these requirements if it based its standards on those developed by certain international organizations, particularly the Codex Alimentarius Com-

mission. However, the provisions will permit an individual country to maintain sanitary and phytosanitary measures different from, and more stringent than, the relevant international standards as long as there is scientific justification for doing so and as long as the more stringent standard is necessary to maintain a level of protection a particular country determined to be appropriate and is not applied in an arbitrary or discriminatory manner.

One question often raised is whether or not the NAFTA provisions on standards would require the U.S. to weaken its present standards concerning the quality and safety of dairy products as well as animal health in the dairy industry. It is not at all clear whether the NAFTA standards provisions would have this effect, but it is one of the outstanding questions to which we need more definitive answers before we can fully assess the potential costs and benefits of the NAFTA for our industry.

Ultimately, the impact of NAFTA on the U.S. dairy industry would depend upon whether it would result in either a greater volume of net exports of U.S.-produced dairy products to Mexico or a greater volume of net U.S. dairy imports from Mexico and elsewhere. This, in turn, would depend on such factors as the future growth of commercial demand for dairy products in Mexico, how the Mexican dairy industry would respond, changes in world dairy markets, the degree to which the U.S. Administration remains committed to the use of export subsidies to counter EC and other subsidies in the Mexican market, and the effectiveness of the rules of origin in practice. A related issue is whether or not Mexican milk producers will be able to operate at a significant cost advantage compared to our dairy farmers due to lower labor costs, lower environmental compliance costs and a reduction in feed costs as a result of NAFTA. However, most economic studies that have been completed to date indicate that NAFTA will have a positive impact on the U.S. dairy industry.

Uruguay Round Negotiations under the GATT

Although no agreement has been reached yet in the Uruguay Round negotiations under the GATT, most of the major agricultural issues have actually been settled for now following a bilateral agreement between the U.S. and the EC last fall. But if the negotiations continue to drag on, this agreement will undoubtedly begin to erode.

A Uruguay Round agreement would also affect the U.S. dairy industry primarily through its provisions on market access, export subsidies and sanitary and phytosanitary standards. Where things stand now under the various Uruguay Round draft agreements in agriculture is roughly as follows:

- Non-tariff import measures, such as import quotas, variable import levies and import licensing requirements would be converted to tariff-rate quotas for which 1) the quota levels would represent at least 3 percent of domestic consumption in the first year of the agreement and at least 5 percent of domestic consumption at the end of a six-year implementation or transition period, and 2) imports above these tariff-rate quota levels would be subject to much higher over-quota tariffs, which would be reduced by a minimum of 15 percent during the six-year implementation period.

- Furthermore, under the draft Uruguay Round agreements, the "Section 22 waiver" which allows the U.S. to impose dairy import quotas under the authority of the U.S. Section 22 law without being inconsistent with current GATT rules, would be terminated.

- Also, and very significantly, expenditures used to subsidize exports of agricultural commodities would be reduced from their average levels during the period 1986-90 by 36 percent over the six-year transition period and quantities of agricultural commodities exported with the aid of subsidies would be reduced from their average levels during the period 1986-90 by 21 percent over the six-year implementation period.

Based NMPF's analysis, implementation of these market access and export subsidy provisions, as specified in the specific offer the U.S. has made in the negotiations, would have the following effects on the U.S. dairy industry at the end of the six-year implementation period: Compared with current dairy imports, imports of additional milkfat totalling .4 billion lbs. milk equivalent, additional nonfat solids totalling .2 billion pounds milk equivalent, and additional cheese totalling .4 billion pounds milk equivalent, would be permitted under the "minimum access" provisions of the U.S. offer through expanded tariff-rate quotas, based on current Section 22 import quotas. In total, additional dairy market access opportunities would total 1.0 billion pounds milk equivalent, compared with current import levels of about 4 billion pounds milk equivalent, with all milk equivalents expressed on a total solids basis; (expressed on a milkfat basis, additional market access opportunities would total 1.4 billion pounds compared with current imports of about 2.6 billion pounds milk equivalent).

Imports of dairy products above these tariff-rate quota levels are possible, but cannot be predicted with any confidence; such imports would depend upon changes in the supply-demand conditions in the U.S. dairy industry and the dairy industries of a number of other countries, changes in world prices, exchange rate fluctuations, and other factors.

Subsidized exports of about .4 billion pounds milk equivalent, of butter and butter oil, slightly more than 1.0 billion pounds milk equivalent, of nonfat dry milk, about 40 mil. lb. of bovine meat, and about 11,400 dairy cows would be permitted by the end of the transition period.

However, such an agreement would also open up additional access to dairy markets in the EC, other European countries, Canada and other countries to U.S. dairy exports. And undoubtedly the single most important benefit to the U.S. dairy industry under a potential Uruguay Round agreement would be the significant reduction in volumes of dairy products exported with the aid of subsidies by the EC. Stronger disciplines on the use of export subsidies would increase world dairy product prices and free up a substantial amount of export demand that is currently being served by the EC through the use of subsidies. Quantitative estimates of these potential positive impacts of a Uruguay Round agreement on the U.S. dairy industry have not yet been developed.

The Uruguay Round draft agreements also contain new rules on sanitary and phytosanitary measures. In the main, these are very similar to the NAFTA provisions on standards. Indeed, the provisions on standards contained in the NAFTA, for which negotiations were begun several years after the Uruguay Round negotiations were launched, were modelled largely on the draft provisions on standards that had been developed several years ago in the GATT talks.

Final Comment

An eventual Uruguay Round agreement, the North American Free Trade Agreement, as well as potential future bilateral trade agreements with Latin American and Asian countries would provide additional access for U.S. dairy exports to other countries. Under such trade agreements, U.S. dairy markets will also gradually become more open to additional imports. Overall, the U.S. dairy industry, along with other agricultural sectors, will face an increasingly open world trading system in the future.

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NOTES

**European
Milk Quotas —
Success Or
Failure?**

**J.M. Stansfield, Director
Farm Management Unit
University of Reading, England**

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European Milk Quotas — Success Or Failure?

J.M. Stansfield, Director
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As with many such questions, and particularly those applying to agricultural policy, there is no simple answer; in fact, it all depends who is asked the question!

If put to European politicians with responsibility for treasury matters, most would agree that milk quotas, although costly to the budget, have in fact prevented bankruptcy of the milk fund. Similarly, if put to a British or Dutch dairyman approaching retirement, with no family to continue the business, they will have no time to answer on the way to the bank! The legislation in these two countries in fact allows a relatively straightforward sale or lease of quota, so providing a valuable capital asset.

On the other hand, if the question were put to milk consumers, they would be less enthusiastic, having experienced price increases. When put to young agriculturalists keen to start-up in dairying, or those already in business but eager to expand, then the answer would be unanimous that quotas have been an outright failure.

If, therefore, you delegates were hoping that I would come to this conference and suggest that quotas could be the solution to all, or even some, of your financial problems, I am very sorry to have to disappoint you!

Before outlining the reasons why quotas were introduced, what effects they have produced, and what are their future prospects, let me first put the European dairy industry into context and make some comparisons with the U.S.A.

European Dairying

The E.C. now comprises 12 countries which range markedly in size, population and climate, as well as in the importance of their dairy industry.

Figure 1 demonstrates the importance particularly of Germany and France as major milk producers in Europe, as well as the importance of milk to the total agricultural production, e.g. 32% in the Irish Republic and 21% in the U.K.

Figure 2 shows in pie-chart form, the 1991 share of deliveries for the 10 (longer established) E.C. members.

Dairying is a major source of income on a large number of E.C.'s small and medium sized holdings. Traditionally, it has provided farmers with a regular supply of cash, and for many has also been a most suitable enterprise to get into farming. The Black & White (Holstein type) cow continues to increase in popularity and, in most countries, the importance of protein production increases at the expense of butterfat. Research and development findings continue to assist in the improvement of the efficiency of feeding, and, with the continued developments of milking and manure handling machinery, more time is being devoted to stockmanship, health control and herd management. This situation, although a fact with larger herds, as for example in the U.K. and The Netherlands, is less relevant to many of the smaller herd commonly operated by part-time farmers in some of the other E.C. countries.

When considering the data for production of milk on a worldwide basis, it can be seen (in Table 1) that the E.C. industry is almost double that of the U.S.A. in terms of cow numbers and milk production, but with an even higher proportion of butter, cheese and particularly milk powder production.

Consumption figures for a number of countries for milk, cheese and butter are shown in Figure 3.

Background to Quota Introduction

Following the establishment of the Common Agricultural Policy (CAP) in the late 50's with its open-ended price support policy for milk, together with steadily improving farm productivity, led in the late 70's to a serious overproduction within the community. By this time, the milk sector accounted for almost half of the E.C.'s annual agricultural support expenditure, arising predominantly from the storage and disposal of dairy products.

With the market situation in the early 80's continuing to deteriorate, but with the Commission continually stating that price reduction rather than artificial limits, was the preferred solution to the problem, the decision to abruptly introduce quotas on the 31st March, 1984 was a watershed in the history of the CAP.

Two schemes were introduced known as A and B:

(A) - the quotas applied directly to each farm (implemented for example in Germany)

(B) - the quotas applied through dairies, so allowing averaging between farms. The U.K. with its Milk Marketing Board was in a splendid position to take full advantage of this option.

Stress has been caused to many dairymen, not only from on-going cuts to quotas since 1984, but also due to the frequent changes to the legislation. Levy in the U.K. has only been charged in 5 of the 8 years of the system.

The Milk Marketing Board helps producers control overproduction by publishing a regular quota profile and gives each farmer an individual statement on a monthly basis. With the proposed disbanding of the Board in the near future, this task will no doubt be undertaken by the Ministry of Agriculture & Food.

The Effect of Quotas

As a consequence of quota imposition, milk production on E.C. farms by 1992 was some 12% lower than in 1983. Reduced supplies of milk for manufacturing have led over this period to 25% less butter and 33% less skimmed milk powder production. The effect on U.K. milk production has been even more dramatic as shown in Table 3.

Cow numbers continue to fall, but after an initial fall in yield per cow, this has since recovered.

Initially, quotas gave producers an incentive to look more critically at their production systems. Many reduced concentrate feeding levels, achieving higher margins from improved production and utilization of forage feeds. In more recent years, concentrate feeding levels have increased again, perhaps stimulated by a better milk:feed cost ratio.

The quota system has no doubt achieved its immediate objectives, but overproduction has still not been solved. The E.C. still has 15% surplus milk to domestic utilization, 20% of the budget expenditure is incurred by milk. Some farmers have moved into other enterprises such as beef, sheep and cereals. As these commodities are also in oversupply, little benefit has been achieved

in terms of profitability and in fact in the 1992 CAP Reforms, both sheep and beef quotas were introduced.

A desk study undertaken by Kirke & Moss in Northern Ireland using linear programming, showed that a milk price cut of 14-16% would have been required to obtain the same reduction in output as from quotas. The study, supported by a number of surveys of actual producer performance, indicate that incomes of dairymen, when adjusted for inflation are very similar to those years prior to quota introduction. Had milk prices fallen by 25%, and assuming all other factors were unchanged, dairy farmers profits would, according to the study, have fallen by 15%. It also showed that many more small and medium sized producers would have ceased production than has actually happened.

Response to quota imposition has, of course, varied from one country to another. In Denmark for example, production has fallen by 15%, number of producers by 33% and, although quota is linked closely to land, 20% of the total quota has been transferred to other producers. Milk price has increased, so raising the demand for quota.

In France, strong measures to persuade producers to 'quit' were introduced, resulting in 38% of the farmers with less than 30 cattle leaving the industry. Their system of quota transfers is complex so that asset values have not been created as they have in the U.K.

It is generally understood that in Italy, the introduction of quotas has not as yet been fully implemented.

The Problems

The major problem which has been experienced by individual dairymen from the introduction of quotas is the considerable restriction to herd establishment and expansion.

In the U.K., to add one extra cow to the milking herd, currently costs (rearing a heifer to 24 months) some £950 or \$1400. In order to sell the milk from this animal the cost of quota purchase, say 7,500 litres at 36 pence/litre = £2700 or \$4050 (approaching 3x the cost of the heifer).

Leasing for one production year is an alternative strategy of obtaining quota in the U.K. (but not in other countries). The cost is some 5p per litre or 30% of the milk sale value of that litre. It is a matter for political debate rather than economic assumption as to whether society has a responsibility to support the incomes of those who in future decide to enter, at their own risk, a highly-controlled industry which is still in surplus. In Germany one can only transfer 5000 litres per hectare (9580 lbs per acre) and in the deal 1000 litres (4600 lbs) has to be surrendered to the State for reallocation to deserving applicants.

If a flexible, uncomplicated (not tied directly to land) system of transfer can be developed, then in theory the efficient (usually larger) producers should be able to take over the quota of the less efficient.

Another problem is caused by quota being 'attached' to land in situations where the dairyman is a tenant farmer. The allocation of quota belonging to him rather than the landowner, has caused numerous disputes if and when tenants wish to retire or move to other farms. The 'standard' agreement is 30% to tenant and 70% to landlord, but if milk production was not taking place when the tenancy was first established, tenants have been allocated a higher proportion. Yet another lucrative job for the lawyers (attorneys)!

Conclusion

The use of quotas to control E.C. milk output has been relatively effective and appears not to have seriously affected producers profitability. In the countries which have allowed uncompli-

cated sale or lease of quota, then considerable asset values for existing producers have been created. However, major problems have been created for first time dairymen and for those wishing to expand.

The more progressive, risk-taking dairymen have, despite the problems, continued to expand, but one can assume at a much slower rate than would have been possible without quotas.

Serious effects have also been experienced in the 'down-stream' industries from the farm — in milk processing plants where reduced throughput has necessitated the need to cut capacity, which has led to major staff redundancies.

The E.C. obviously considers that quotas in some form or another are at least partially successful, hence the recent introduction of quotas in sheep and beef production.

Current E.C. policy suggests that milk quotas will be around at least until the year 2000 — which should give some stability to the dairy industry, which at present is probably the most profitable agricultural enterprise to be involved in.

Quotas may have been a relative success in Europe, but would appear to have minimal attractions to Western U.S. dairymen and especially to today's delegates, who no doubt have continued herd expansion as a major objective.

TABLE 1

WORLD PRODUCTION OF MILK AND DAIRY PRODUCTS, 1991

Country	No. of Dairy Cows '000	Production ('000 tonnes)					
		Cows Milk	Butter (factory)	Cheese (factory, incl. fresh)	Milk Powder		
					Whole	Skim	Total
EC	23,098	113,241	1,738.0	5,191.0	980.0	1,513.0	2,493.0
Other W. Europe	2,972	14,882	183.6	495.4	40.9	115.1	156.0
Eastern Europe	53,530	132,116	1,967.3	2,752.5	377.3	1,036.5	1,413.8
Canada	1,996	7,240	96.7	290.7	8.3	77.3	85.6
USA	9,990	67,370	607.7	3,180.7	52.2	408.3	460.5
Total N. America	11,986	74,610	704.4	3,471.4	60.5	485.6	546.1
South America	23,250	23,091	111.0	432.4	292.0	28.0	320.0
Rest of the World	66,895	53,509	1,172.0	1,677.0	128.0	161.0	289.0
Total World	217,950	461,193	7,309.8	14,406.0	2,272.1	3,790.0	6,062.1
EC as % of Total	10.6	24.6	23.8	36.0	43.1	39.9	41.1
USA as % of Total	5.0	15.0	8.0	22.0	2.0	11.0	8.0

TABLE 2**U.K. YEAR END WHOLESALE QUOTA POSITION SINCE 1984**

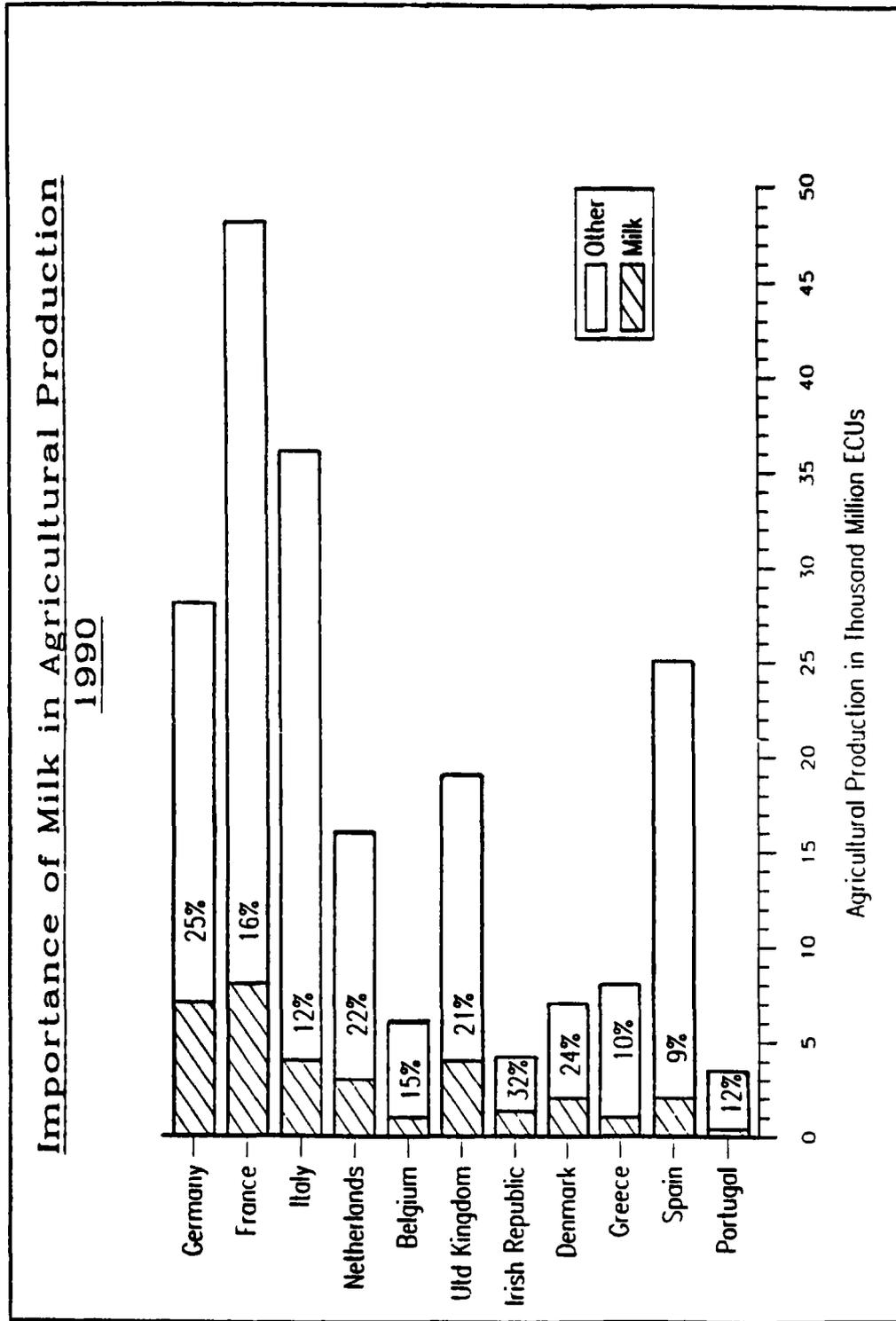
Year	Above or Below Quota	Levy	Threshold
84/85	Below	No Levy	-
85/86	Above	0.14 ppl	-
86/87	Above	3.49 ppl	-
87/88	Above	19.08 ppl	+7.97%
88/89	Above	19.64 ppl	+3.61%
89/90	Below	No Levy	-
90/91	Above	24.07 ppl	+5.71%
91/92	Below	No Levy	-

TABLE 3**MILK PRODUCTION IN THE UNITED KINGDOM**

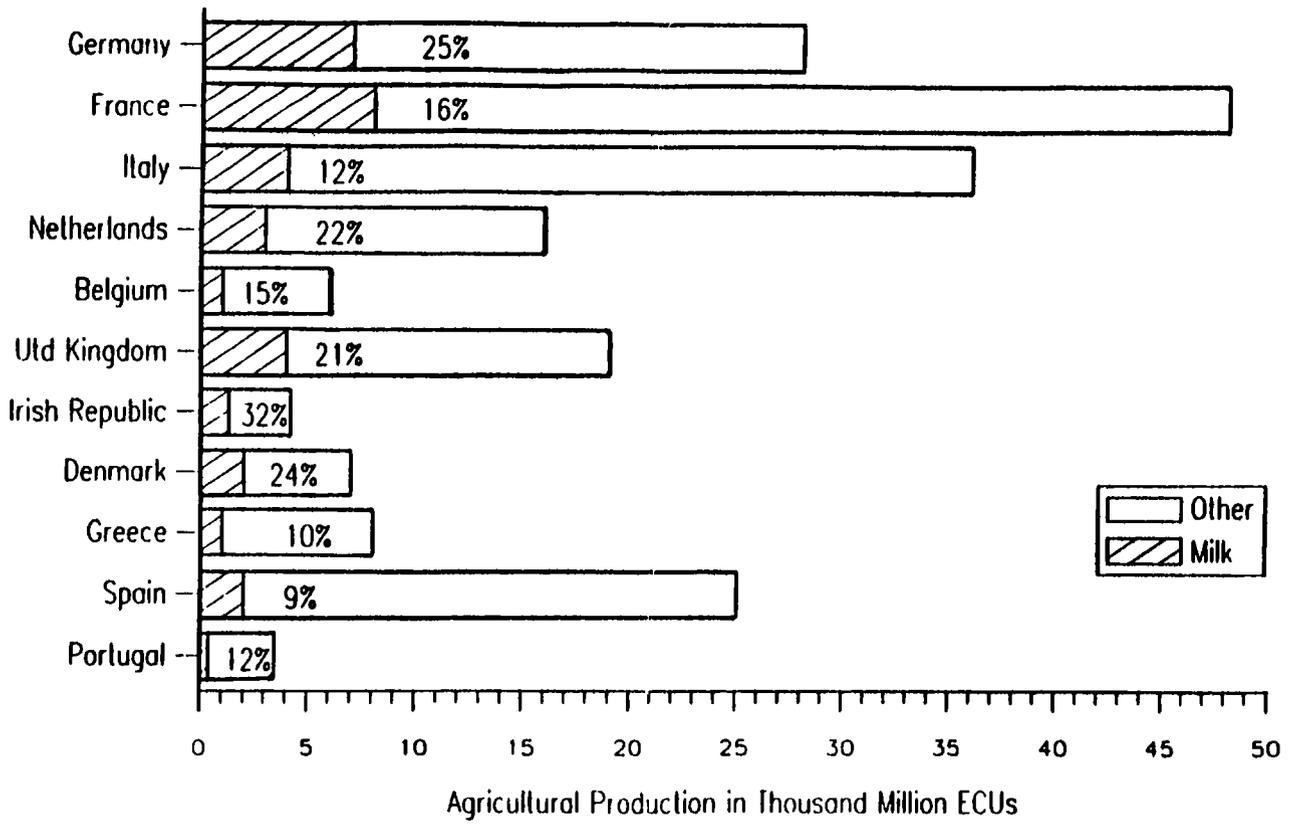
	1983	1990	% change
Dairy cows ('000)	3,368	2,869	- 15
Yield per cow (litres/year)	4,968	5,148	+ 4
Milk output:			
- (m litres)	16,729	14,771	- 12
- (£m current prices)	2,497	2,804	+ 12
- (£m 1990 prices)	3,727	2,804	- 25
Manufacture ('000 tonnes):			
- butter	241	142	- 41
- skimmed milk powder	324	170	- 48

Source: Ministry of Agriculture, Fisheries & Food (MAFF) annual publications: Agriculture in the United Kingdom, Annual Review of Agriculture and Milk Marketing Board (MMB) annual publication: UK Dairy Facts and Figures.

FIGURE 1



Source: European Facts & Figures.



Source: European Facts & Figures.

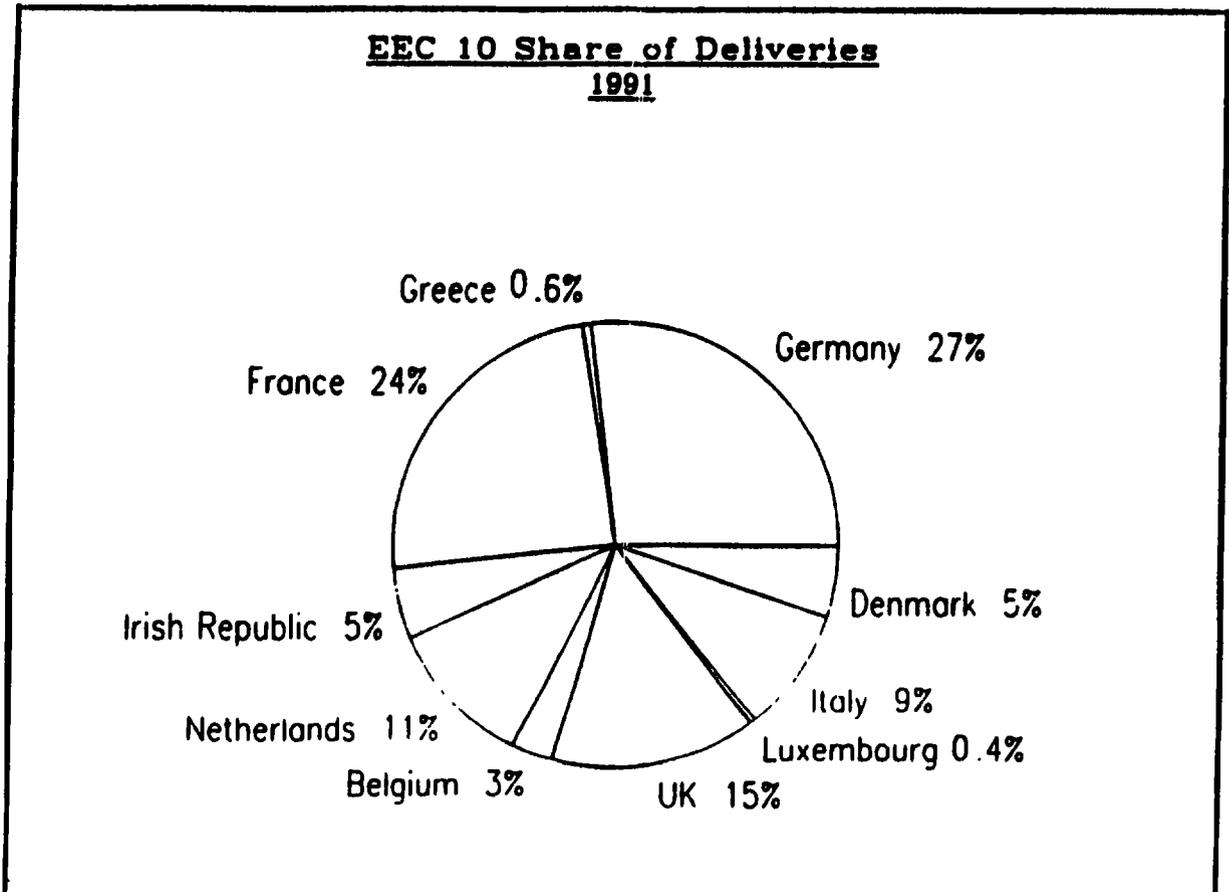
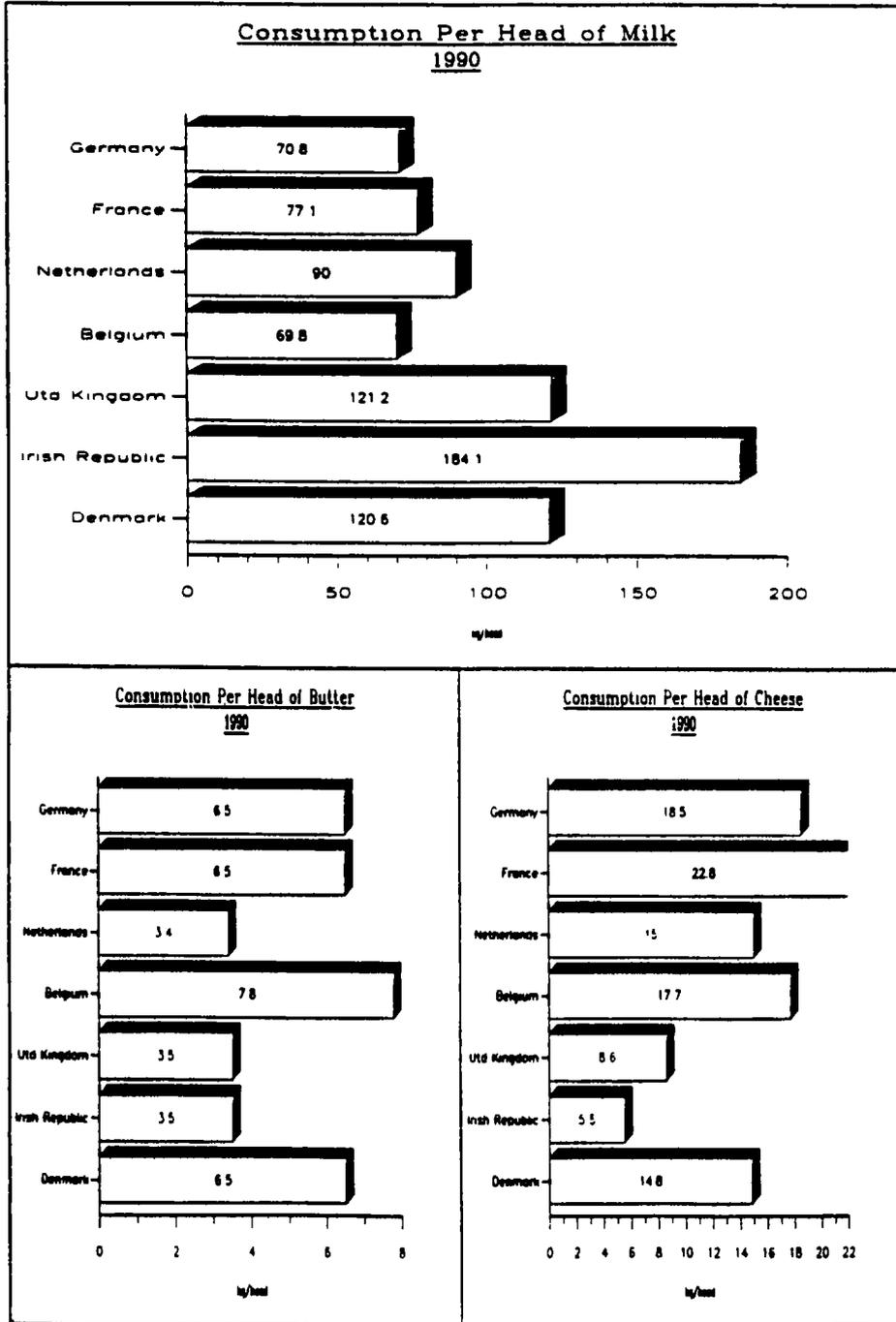


FIGURE 3



Total Quality And The Dairy Farm Business Organization

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Total Quality And The Dairy Farm Business Organization

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First, Improve the Quality of Management.

Second, Improve the Management of Quality.

Management is the key to the successful operation of any business. In agriculture we have viewed management as a generic term describing essentially anything dealing with the successful operation of a farm business. We have failed to give the term definition and rigor. The result is that management itself has not been a subject of study or improvement for the dairy industry and has become an almost mystical term we use to explain why some farms have higher productivity and/or profitability. In contrast, other sectors of the economy, clearly identify management separate from their production technology and seek to improve it. Current thinking in management concerns itself with "Total Quality Management." In this paper Quality Management is viewed as the key for improving and operating a dairy farm business organization.

In this paper we will first explore management and the concepts of total quality management. Then the application of quality management to the dairy farm organization will be examined concluding with a discussion of delegation as a means for decentralizing our dairy organizations in order to improve effectiveness and implementation of quality management.

Management

"Management is Determining what must be done and achieving results through the efforts of oneself and other people. Management is planning, organizing, staffing, directing, and controlling the business resources toward the accomplishment of established goals."

The Five Management Functions

The five functions of planning, organizing, staffing, directing, and controlling are outlined in the management wheel (Figure 1). Each are described in more detail in the following definitions:

- **Planning** is the ongoing process of developing the farm business' mission, objectives, goals and detailed tactics which will clearly focus activities toward the most productive and rewarding ends. Planning also involves the process of problem solving which includes decision making.
- **Organizing** is establishing an internal framework for the farm business. This structure clearly defines the roles and activities required of people in order to meet the objectives of the farm business. The manager must decide the positions to be filled and the duties, responsibilities, and authority attached to each one. Organizing also includes the coordination of efforts among people and enterprises.
- **Staffing** is recruiting, hiring, training, evaluating, and compensating oneself and other people. This includes finding the right person for each job and keeping manned the positions required

by the organizational framework.

- Directing is leading, coaching, delegating and motivating people. Directing involves communicating with people to develop and improve the environment in which people enthusiastically carry out their roles in the organization.

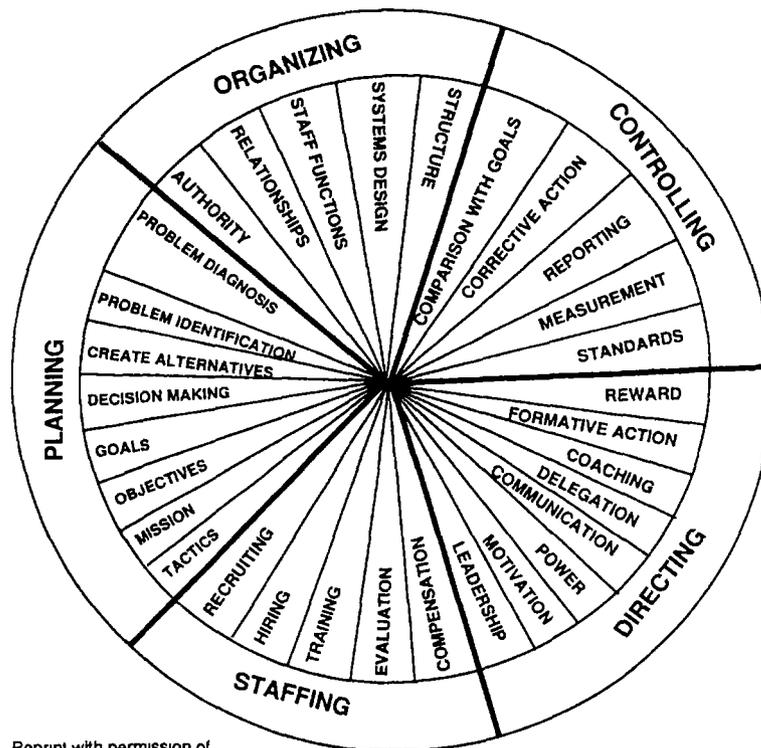
- Controlling is measuring and reporting actual performance against set standards and taking appropriate corrective actions when events are not conforming to plans.

All of the activities of management can be analyzed as a part of one of these basic functions. All management challenges can be diagnosed as having a root management cause in one of these functions. Each pie shaped slice in the following figure is a smaller component of the basic five functions.

Total Quality Management

The concept and practice of Total Quality management which was introduced to Japan after World War II by Professor Demming of the United States has made Japan an economic success. These same principals and practices are sweeping and reforming industry in the united states. Congress has established the Bauldrige award for quality and you can see the quality emphasis of many companies even being put into their slogans for example "Quality is Job One". We in agriculture can benefit from this orientation as well. Quality forage, quality milk, quality young stock, quality organizations can all be achieved through the principals and practices of total quality management. The basic concepts of quality management are reflected in the following graphic.

FUNCTIONS OF THE FARM MANAGER



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Total quality management is focused on several ideas reflected in the definitions that follow. Quality management requires that we look at the farm in a different way and take on a customer orientation rather than a producer orientation. If we think of each activity on the farm, like haying as a process and each product, like forage as an output being produced for a customer, like the herd manager than this will make some sense. Following this example, a customer might be the herd manager the process may be producing forage, the supplier may be a crop manager. The herdsman takes forage as an input for his customer the cow. The idea is that every activity on the farm should be aimed at giving a customer the highest quality products and exceeding their expectations for service. Total Quality is based on making continuous improvement through a team effort. Even if there is only one person doing all the work the principals are the same.

Total Quality: The continuous improvement of processes in response to internal and external customer needs through the total involvement of people.

Customers: The individuals who receive outputs from suppliers (receivers)

Suppliers: The individuals who provide inputs such as information (senders) of inputs for a process.

Process: The activities that individuals and teams engage in to convert inputs to outputs.

Inputs: Materials, energy, information or other measurable tangibles which, through a process, are converted to outputs.

Outputs: The results of a process, Outputs are tangible and measurable.

As we begin to successfully understand our role as serving the needs of customers than we begin to listen to their needs so we can serve them better. The dairy of tomorrow is already listening to the consumers interest in not only the direct products of production such as milk and cheese but the by-products of production such as concentrated nitrogen and reduced ground water. These non-market issues of sustainable agriculture will continue to challenge and make complex the objectives of the farm organization. This fact makes it even more critical that our organizations be effective and smooth running so we can meet these ongoing challenges.

Dairy Farm Business Organizational Development

Perhaps the most significant change as farm businesses become larger is the increasing organizational and managerial complexity of the business. Two specific changes are the increasing size of the management staff on particularly large farm businesses and the increasing proportion of time managers spend managing. Farm businesses with two levels of management (managers under the supervision of managers), which were almost nonexistent not too many years ago, are fairly common today.

Like managers, organizations grow and develop over time and problems often arise when the organization and the manager are "out of sync" with one another. Farm managers often find it easier to think of changing something physical or technical than to think of changing their organization or management practices. Good managers must, however, constantly examine their own performance as manager and the appropriateness of their organization in meeting the challenges of

the day.

Organizational Structure

Organizational structure is how the business is organized to perform the function of the business. Most farm businesses progress from the informal family patriarchy to a fully developed, functionally specialized, and decentralized team structure. The type of structure employed on a farm is a function of management philosophy, the ability and availability of middle management and the size of the organization. Structure in its highest form becomes a tool in the hands of the manager to influence all other aspects of the business, employee performance, and productivity.

In this section we consider several principals key to developing an effective organizational structure, we delineate the conditions necessary for effective business operation, and we consider the alternative organizational structures.

Principals of Organizational Structure

While no farms organizations are exactly alike, there are certain fundamental characteristics common to all and, therefore, some basic procedures which, when adhered to, can help insure total organizational effectiveness. The following list of principles is not complete, but it does represent some of the more important factors which must be given consideration when structuring the farm organization for success.

Principle of Objectives: Prerequisite to the starting of any organization or to carrying on any activity is a clear and complete statement of the objectives in view. Only after this can the operation be built and molded to foster the attainment of those objectives with the least amount of effort and cost. Objectives can also serve to give the farm a sense of direction and purpose on a continuing basis. Conversely, without objectives there is a greater possibility that the farm will drift and not respond adequately to its environment. This critical principal requires that the manager exercise leadership and planning to convey clearly the vision of the farm to all members of the team.

Principle of Coordination: The organizational framework on the farm must provide for the integration and blending of both human and technical resources. Coordination results when the systems and procedures which are established facilitate the accomplishment of results and when each unit of the organization thoroughly understands the role and the function of every other unit. Another aspect of coordination concerns the establishment of effective channels of communication as well as the creation of a total team climate. A customer orientation facilitates this coordination.

Principle of Parity of Authority, Responsibility, and Accountability: When an individual is held responsible for a task, he must also be given the authority necessary to perform it. If the assigned responsibility is greater than the authority which is granted, then responsibility will tend to shrink within the limits of the authority. If the opposite is true, that is, more authority is granted than is needed to meet a given responsibility, then there will be a tendency for responsibility to expand. In any case, accountability can only be expected within the limits of the authority extended.

Principle of Unity of Command: Each employee should be held accountable and answerable to only one supervisor. If an employee is receiving directions from more than one supervisor, there is a strong possibility that confusion will arise. This is particularly true when what he is being told is not the same. He will find himself stuck in the middle. The result is usually either halfway action

or no action at all.

Principle of Delegation: The need for organization arises when one man cannot do a job alone. Thus, other people are employed and some type of organizational structure appears. If, however, the people who are brought in are to make a meaningful contribution and be productive, then true managerial delegation must take place. Delegation is the process by which a manager assigns responsibility, grants authority, and creates accountability. Without delegation, the manager will defeat his own purpose of bringing others into the operation. He will end up doing everything himself.

These principles are not presented as hard and fast rules which always reflect the reality of organizational life. They do, however, present the manager with some fundamental guidelines which are of value when analyzing how effectively the organization is functioning on a day-to-day basis. Farm operations run most efficiently and people integrate their efforts best when the following conditions are present:

- When each person is aware of the overall objectives of the farm and the specific goals supporting each objective.
- When each person has played an active role in determining what the objectives are, or at a minimum, in planning how they can best be achieved. When each person is thoroughly briefed on the role and function of other members of the team and has a clear understanding of the purpose or rationale behind the various functions.
- When a method is built into the organization structure for people to come together and interact in a climate conducive to open communication and problem solving as opposed to defensive behavior.
- When lines of responsibility, accountability, and authority have been clearly established and are understood by all the people.
- When an atmosphere of "team effort" prevails and each member of the team is committed to the task at hand, as well as to understanding and appreciating others.

The attainment of these conditions is an important objective of the organizing function of management. Through continuous improvement, managers must develop an organizational structure that will attain these conditions. Organizational structures range from the highly centralized to the very decentralized. To meet the challenges of today a more decentralized team orientated structure must be adopted. This type of organizational structure is principally achieved through delegation.

Delegation

Delegation is the achievement by a manager of definite, specified results, results previously determined on the basis of a priority of needs by empowering and motivating subordinates to accomplish all or part of the specific results for which the manager has final accountability. The specific results for which the subordinates are accountable are clearly delineated in advance in terms of output required and time allowed and the subordinates progress is monitored continu-

ously during the time period. (McConkey, 1974)

In simpler terms, Delegation is the process by which a manager assigns responsibility, transfers decision-making authority and creates accountability to meet the objectives of the business.

The right to decide the allocation of resources rests with the owner of those resources. However, he/she may give someone else (an employed manager or outside consultant, for example) the authority to exercise this right on his/her behalf. The act of assigning this "right to decide" constitutes delegation. Effective delegation does not happen naturally. It must be accomplished the old-fashioned way through conscious effort and hard work. However, the successful delegation will pay off in productivity, efficiency, human resource development; and, in the long run, profitability. Below, the steps to effective delegation are listed.

Steps for Effective Delegation

1. A clear description of what is being delegated and the desired results of the delegation in the form of a clear objective or end result.
2. Why you are delegating.
3. Why this particular delegate has been chosen.
4. The scope of the authority being transferred to the delegate.
5. Any confidentiality, special interpersonal information or sensitive issues involved.
6. Introduce others with whom the delegate may be working and inform others who will need to know the new distribution of authority.
7. Explain any relevant time constraints, along with all other resources and their limitations which will be put at the delegates disposal.
8. Establish controls, including the types of information and progress reports that are desired to assure successful accomplishment of objectives.
9. Provide time to insure delegate feedback and understanding.

Summary

Management must first be improved before the dairy farm business can attempt to manage quality. Further, to improve quality the farm organization must take on a team structure through the decentralization of decision making authority brought about by effective delegation.

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Using Records For Large Herd Management

**Michael A. Tomaszewski
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Using Records For Large Herd Management

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Dairy producers have had access to systematic structured record programs since 1905. A key feature of those programs was a clearly defined flow structure for data to a central data base. For example, data flowed to the Animal Improvement Programs Laboratory for genetic evaluation and breed associations for registry work. Unfortunately, there was no reverse data flow. That is, a producer did not have ready access to his data files to use in herd management.

As computer technologies, especially microcomputers, have revolutionized the way in which data were calculated, new opportunities became available to move record management from a data gathering to a data evaluation system. Unfortunately, historical providers of dairy programs failed to appreciate the added power of on farm microcomputers and the resultant shift in needs and requirements by dairy producers for data base access.

Computational power has increased exponentially while cost has decreased in the same manner. This has resulted in an opportunity for dairy producers to evaluate management opportunities using their own on farm data base. No longer are producers limited to pre-defined forms or calculations that some “expert” felt the dairyman need to manage his dairy herd. Rather, with the new generation of software, he is no longer constrained by pre-defined reports and has the power to access his data base.

Today, the key issue in large herd management is access to “your” database. Data base access provides ways beyond historical “DHI” type programs to manage herds. Several programs are available that allow for this inside look at your database.

Current Test Day Analysis

One such program is the current test day analysis program (CTAP) that provides a sensitive way to evaluate management of a herd.

The basic design of the current test day (CTD) production profile is to divide the herd by stage of lactation (days in milk (DIM)) and by lactation number. The DIM divisions are <45, 45-100, 101-200, 201-300 and >300. Animals < 45 DIM are considered “fresh cows” or “start up cows”. The <45 DIM also identifies animals with typically only one test day value. This group typically across herds will average approximately 20-25 DIM. The 45-100 DIM group are considered “peak cows”. Across herds this group will average approximately 65-70 DIM. The 101-200 DIM group are termed “middle lactation” animals. The 201-300 DIM group are termed “late lactation” cows. The >300 DIM group are termed “long lactation” cows. This group typically contains reproductive problem cows who are above herd average in production.

The purpose of the CTD production profile to evaluate CTD production trends in a herd with the ultimate purpose to evaluate the current nutritional status of the herd.

The absolute values of milk pounds, fat percent and protein percent are strong indicators of the pre-partum body condition and nutritional management. Typically Holstein cattle will average 3.6 to 3.8 percent milk fat and 3.2 to 3.4 percent milk protein on start up animals

regardless of parity group. Jersey cattle will average 4.0 to 4.2 percent milk fat and 3.4 to 3.6 percent on start up animals regardless of parity group.

Milk fat values averaging greater than 4.0 percent (on Holsteins) as a group indicate that some of the individuals in this group will have elevated milk fat percent values. Elevated milk fat values are an indication of abnormal metabolism of body stores and assimilation of fatty acids by the Krebs cycle in the liver. Elevated milk fat values are typically seen in animals whom are over conditioned at calving or who have undergone extreme changes in body condition. If milk protein values are elevated with slightly depressed but not inverted milk fat percent values this may be an indication of udder health problems in the herd. Elevated milk protein percent in combination with a milk fat inversion is an indication of a poor energy protein relationship in the diet.

Milk fat percent below 3.6 to 3.8 percent are an indication that there is a lack of overall (energy) body stores in the animal. These animals are thin at calving. Milk protein below 3.1 percent in combination with an elevated fat percent is an indication that there is a lack of protein body stores in the animal. This is a common occurrence in animals fed high energy with low protein diets pre-partum.

The change in absolute value of milk pounds, fat percent and protein percent between start up and peak lactation groups. The amplitude of peak milk difference in combination with start up milk pounds has a very strong correlation to the 305 day lactation yield of a cow. Typical peak milk difference values range from 5 to 12 pounds regardless of breed. Peak milk difference is influenced by parity group. If peak milk difference is low or negative it may indicate; transition cow management problems, poor body condition or short dry periods. It usually takes about 40 to 60 days to see increases in start up milk values translate into increases in peak milk.

Large peak milk differences or delayed peaks are uncommon but typically indicates poor pre-partum (dry cow or heifer) nutrition.

Changes in milk component percents are sensitive indicators of rumen health. The normal decline in milk fat percent between start up and peak lactation is .4 to .5 units. Declines in milk fat percent greater than this are an indication of acidosis and/or extreme body weight loss.

Milk fat and protein percent may increase from start up to peak but this is unusual. Milk protein values which increase from start up to peak with a large decrease in milk fat percent between start up and peak milk is an indication of over conditioned animals who are deficient in protein. If both milk fat and milk protein increase from start up to peak this is an indication that the animals were nutrient deficient prior to calving.

When milk fat and milk protein percent become inverted (milk protein is greater than milk fat), this is an indication of abnormal rumen function in a dairy cow. This can be caused by overfeeding grain, poor rumen carbohydrate protein relationships, severe body weight loss or by feeding ionophores.

The trend of the change in absolute values for fat percent and protein percent between peak, middle, late and long lactation groups. Once the animal has passed peak milk flow, milk fat percent and milk protein percent should increase at a steady rate from peak to middle to late lactation. Long lactation animals may deviate a little bit based on days in milk. Milk fat percent and milk protein percent values are sensitive indicators of body store repletion in a dairy cow.

If milk fat percent and milk protein percent invert after peak milk flow it usually is an indication of a group change. Milk fat percent and milk protein percent are strongly influenced

by the acetic to propionic acid ratio; therefore anything that will alter this ratio will also alter the milk fat to milk protein ratio (examples; body condition, feeding programs and feed additives).

The interval change in milk production between peak, middle, late and long lactation groups compares changes in milk production this month across stages of lactation. The normal change in milk production is 10-15 percent across lactation groups (parity) and stage of lactation. First lactation animals fed total mixed rations (TMR) tend to have very small interval persistency values. This is a desirable trait. The interval change in milk production in long lactation cows may be influenced by the number of observations in the group as well as the average days in milk of the group. If there are a limited number of observations in this group the interval persistency may be greater than 100 percent. The cattle in the long lactation group tend to be reproductive problem cows who are above herd average in milk production. This can be verified by evaluating the days dry, days open and mature equivalent production averages of this group.

The average days dry (DD) in second, third and greater and all lactation groups. The average number of DD in the animals fresh this month (<45 DIM) in second and third and greater lactation groups as compared to the lactation group average.

The ideal DD of a herd will vary considerably from herd to herd. The dry period serves as a resting period between lactations. Therefore, first lactation animals will not normally have dry days. If this occurs it is usually one animal or a small group of animals who were recently purchased and entered the herd. If the DD is outside (high or low) the ideal range (as determined by the analyst) it will affect peak milk flow. The CTD production profile allows the analyst to evaluate the DD dry between first and second lactation as well as second and third and greater lactations. In addition the DD of the animals fresh this month (<45 DIM) as compared to the yearly average can also be evaluated.

The relationship of the milk fat percent and protein percent in late and long lactation animals in first lactation as compared to the start up fat percent and protein percent in second lactation animals. This trend is also evaluated between second and third and greater lactation animals.

The use of Student's T test verifies that the milk fat percent of the last test day of first lactation is approximately equal to the start up milk fat percent of second lactation. The milk fat percent of the last test day of second lactation is approximately equal to the start up milk fat percent of third lactation.

When the milk fat percent of the last sample day of the first lactation is greater than the milk fat percent of the first sample day of the second lactation this is an indication that the animals lost weight and or body condition between first and second lactations.

When the milk fat percent of the last sample day of the first lactation is less than the milk fat percent of the first sample day of the second lactation this is an indication that the animals gained weight and or body condition between first and second lactations.

When the milk fat percent of the last sample day of the second lactation is greater than the milk fat percent of the first sample day of the third lactation this is an indication that the animals lost weight and or body condition between second and third lactations.

When the milk fat percent of the last sample day of the second lactation is less than the milk fat percent of the first sample day of the third lactation this is an indication that the animals lost weight and or body condition between second and third lactations.

Lactation Curves

Another way to look at herd performance is to monitor lactation curves. A lactation curve is a set of points graphically displaying the production output of a cow or group of cows over a period of time. Curves may be drawn for milk, milk fat, protein, somatic cells, and body condition scores, to name a few. By viewing a graphical representation of his herd, a producer is able to recognize a shortcoming without wading through a pile of numbers.

Lactation curves are not only useful for determining general trends in the main herd, but also for re-grouping the herd into calving groups, feeding groups or by individual cows. Patterns emerge that represent a critical area. Two major contributions to decreased lactation milk production become evident upon examination. They are peak milk production and persistency of lactation.

Lactation curves provide a means to highlight herd weaknesses and show differences among certain groups. For example, in comparing first lactation cows to older cows, it is known that first lactation cows peak lower, but are more persistent in production. The difference in curves is readily apparent when the two are compared side by side. Thus, providing a way to determine if they are receiving proper management. Another way is to compare herds with standard curves.

Milk production graphs along with milk fat and protein percent curves provide an additional means of pinpointing management opportunities. Fat percent provides clues as to the adequacy of the ration. The fat-to-protein relationship also bears examination, because it is normally a stable relationship, except when management practices cause it to fluctuate such as body weight loss or changes associated with group changes. Graphs of somatic cells provide the producers with another method of monitoring cow health and production. Since somatic cell counts are related to level of milk production and mastitis status.

Your Data Base

Microcomputers have redefined and restructures the process of managing your dairy herd. Using programs to access on farm data bases will increase a producers ability to realize and maintain profit in today's roller coaster milk market. You now have the ability to manage your dairy herd from your data base. Use this resource to increase your ability to be in charge of your herd management opportunities.

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Motivating
Dairy Farm
Employees:
It's Not At All
What You Might
Expect

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Motivating Dairy Farm Employees: It's Not At All What You Might Expect

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The large dairy production units of the Western United States are significant business institutions. Large dairy businesses handle millions of dollars in cash and equity. They require a large staff of employees to accomplish the multitude of tasks that must be accomplished daily. Superior employee performance is vital if the business is to remain solvent and competitive. Several significant changes are propelling the industry to become more like classical "big business" and much less like the 40-cow family farm of old. The lucrative federal system of milk price supports is all but gone. The federal system will never be the market clearing force it once was.

The net effect of this change will force dairies to adopt greater and greater economies of scale. This scale will require a greater number of employees involved in the production of milk. Other significant changes are the demographics of the employees and employment law. The typical dairy farm employee is better educated, may be bilingual and is more interested in upward movement in society. More and more farm workers in the West are integrating into the urban economy in a wide variety of business. Dairy employers will have to compete with their urban counterparts. As politics and legislation continue to focus on the farm employment arena, farm labor law will change. Current and future labor law works to ensure the rights of farm workers. A number of farm worker organizations carefully monitor employer-employee relations to guarantee the rights of the employee. Their effort's center on education and legal action.

The history of worker relations and management in the coal mines and the factories of the early 1900's reads quite similar to the modern stories of the success and tragedy of the farm worker. Major change in the philosophy of employee management within "big business" in this country did not occur as a result of educational enlightenment of the US business manager. Rather the Japanese listened to our business schools, people like Dr. Edward Demming, and nearly beat us at our own game. Modern business learned out of necessity.

Agriculture and especially the dairy industry in the West need not blindly repeat the mistakes of businesses, like the auto industry. Large dairy farms have a golden opportunity to learn from the mistakes others have made and become excellent people managers. There are faint signs this change begun. The purpose of this discussion is to fan the fire of change and provide some simple insights that will facilitate the process.

We come back to the issue that seems to be on the minds of managers of large farms. How do you motivate employees? The answer is you can't. They are already motivated. Back in 1968, Dr. Frederick Herzberg in his work with the manufacturing sector, showed that all employees are motivated. The problem arises from the management belief that they are not and we need to find clever and unique ways to get them to do what they really don't want to do. Anyone who has raised children knows all about that management theory.

The simplest and surest way to get someone to do something is ASK. If that fails then we have

to deal with the obstinance. We are all masters of that. It is reminiscent of the torture scene in which some gruelish fellow says "we have ways of making you talk" Our modern methods are a lot less bloody, but the effect is the same. The next tactic is to TELL the employee. If the employee does not understand, we have a communication problem. This problem reminds me of the time my dad tried to teach me to drive the car. Since I was not good at mind reading, I didn't do very well. "What we have here is a failure to communicate" or so the line goes in a scene from Cool Hand Luke. The last approach is to SHOW him. Certainly the employee will "get it" if the manager takes time to train and demonstrates the task. "Oh, but that is going to take so much time." "Heck, I might as well do it myself," is a common feeling when confronted with the time and effort needed to train someone. There will always be those who believe it's easier to force the issue and use the KITA approach. KITA has something to do with a foot in the posterior.

There are all kinds of "snake oil" (kita) techniques out there for gettting employees to do more, faster, better and cheaper. Most of those approaches involve KITA in one form or another. There are several forms:

- Negative Physical KITA: The literal application of the term will not to motivate. After the judge passes sentence you probably will change your management style.
- Negative Psychological KITA: Threats, degradation or humiliation do not motivate!
- Positive KITA: Do this job or task and you will receive a reward. Some say this is motivation.

This is really a tactic to get people to do things that they would not do if it were not for the reward. Hence, I conclude they are not intrinsically motivated, rather seduced.

There are valid applications of incentive programs, but let's make the clear distinction that they change behavior without altering the intrinsic motivation of the employee. The question remains, how can we motivate our employees? We can't, but we can provide satisfaction and provide opportunities for employees to fulfill those intrinsic needs, that we all share.

We all work for reasons other than money. Achievement, growth, recognition, social benefits and giving meaning to our existence, all have a lot to do with why we seek meaningful employment. On the list of the "big" motivators there is no mention of working conditions, days off, cash incentives, and health insurance. These factors are important but many researchers suggest they do not provide the motivation that gets us out of bed in the morning and push us to work with pride, commitment and ownership. Dr. Herzberg's research, and that of more than a dozen others, examined the attitudes of workers in many countries and occupations. They found that there are many factors that provide job satisfaction and job dissatisfaction. Curiously, they found the job characteristics that cause extreme job satisfaction or extreme dissatisfaction were seldom the same factor.

Another way of looking at the findings reveals that some factors, like salary and working conditions, were generally associated with reasons for dissatisfaction and were not reasons for extreme satisfaction. In contrast, factors such as job recognition and achievement were associated with extreme satisfaction and seldom with extreme dissatisfaction. The factors associated with extreme job satisfaction (motivation) and dissatisfaction and shown on the chart. The job attributes range from security on the low end of the motivation scale to achievement on the high

end. Take some time to reflect on the management style of your operation or employer. Where is the emphasis placed and what level of motivation exists?

Managers tend to manipulate only the factors in the right half of the chart in the expectation that only they can motivate the employee. Because most employees perceive those factors as satisfiers, their efforts are doomed to fail. However, because the factors represent somewhat of a hierarchy of needs, efforts to provide employee recognition, to increase motivation, in the face of salary dissatisfaction are also doomed.

Given that your employees are driven by a series of relatively constant factors that either only provide very modest satisfaction and others that fulfill the employees' intrinsic desire to work, managers have their work cut out, if they seek exceptional employee commitment and performance. The take home message from Herzberg's chart is place your management emphasis on the employees' strongest motivations.

Where is the real problem, Managers or Employees?

A number of years ago I received a phone call from a very unhappy farm manager. He was complaining, loudly and in expletives, that all milkers of one ethnic type were no ——— good and it was impossible for him to get a single good employee. After listening for some time, I came to a conclusion and I shared it with him. I suggested that just perhaps the reason that he could not find a single good employee had a whole lot more to do with him and his attitude than the attributes in any would-be employee. He angrily said, "What do you mean?" The conversation didn't last long after that.

To my surprise, I have learned that many of the contemporary business analysts, the likes of Tom Peters and Jay Hall, reached the same conclusions. Hall asserts in his book, "The Competence Process," that workers are not the problem, bosses are. We tend to exalt technology and management when things go well. When things go bad we blame the workers. The more enlightened of managers realize that people need to work and do well for their self esteem and mental health. Yet we still manage them as if we need to find clever ways to get them to do things when they are trying to find every way not to. Something is amiss and maybe it is not the employee.

Dairy producer Steve Maddox has led the way in modern employee management in the farm sector. He suggests "The challenge [for management] is to help your employees keep their "edge." The edge is that extra interest and commitment from people getting more than a pay check and eight hours of busy work. Specifically, Steve Maddox found through experience what Herzberg discovered in research: recognition is a powerful tool for employee management. Recognition can be as simple as talking with the employee and seeking their advice or publicly recognizing them for outstanding performance. Recognition ranks second only to achievement in Herzberg's motivators. In the book, *The One Minute Manager*, the power of recognition is beautifully and simply captured in the management advice, "Catch Someone in the Act of Doing Something Right" and by all means tell them about it!

While understanding the motivations of the employee may be easy, implementing a management style that is honest, trustworthy and consistent can be as difficult as changing the personality of the manager. It can be done and it will take practice and conscious daily choice.

Help for managers and Supervisors

Many have come to the conclusion that the biggest obstacle to improving the satisfaction and

the intrinsic motivators in the workplace is the behavior of the manager. Many books, consulting firms and training programs offer training for supervisors. Seek them out and invest time and money in this training for farm managers. We place too great an emphasis on milk production, nutrition, mastitis, business management and forget that the modern farm is only as good as the ability of the manager to implement decisions through the employees.

One concept of the supervisor's role that should be easy for many to relate to is that of "employee coach." The model of the coach is one of a team of workers all desiring the same goals and it is the role of the coach to help the employee improve and reach their personal and common team goals. There are many models for building successful coaches and teams. Let me share one that is simple and easy to implement:

THE MANAGER AS COACH

A. The Lineup.

Who is on the team?

What are their attributes? Analyze their strengths and weaknesses B. What players would be best for which positions?

B. What players would be best for which position

What are their interests and goals?

C. Steps for Building a successful game plan.

1. Buy in and ownership by the players
Do the employees share the goals of the farm are they willing to help?
2. Costs are understood
What do we all stand to gain or lose?
3. Results must be clear, provide recognition for success
Employee performance goals must be clear, and easy to understand
4. Progress is measured
Data is available to all and measures understood
5. Benefits are obvious
Benefits have meaning to employees and managers

D. Coaching Secrets

Rate yourself low (1) to high (5) on these attributes:

1. Be available
2. Promote Participation
3. Build Relationships
4. Delegates
5. Provide Feedback
6. Allow Mistakes
7. Be a Role Model
8. Offer Training
9. Set Goals
10. Have High Expectations

11. Share Information
12. Celebrate Attempts
13. Encourage Teamwork
14. Grow Experts
15. Reward Innovation
16. Have Unannounced Celebrations
17. Say "Thanks"
18. Show Your Emotions (+,-)
19. Pick Your Issues Carefully
20. Be a Team Player

E. Coaches as Communicators

Sending:

Follow up, ask questions, seek clarity

Avoid over communicating

Use "I" statements, Don't attack

Establish ground rules for communications

Receiving:

Active listener

Paraphrase back to sender

Show empathy

Eliminate Defensiveness

Never Assume

F. Coach as Trainer

Remember: EX DEM PRA MON

EXplain

DEMonstrate

PRActice

MONitor

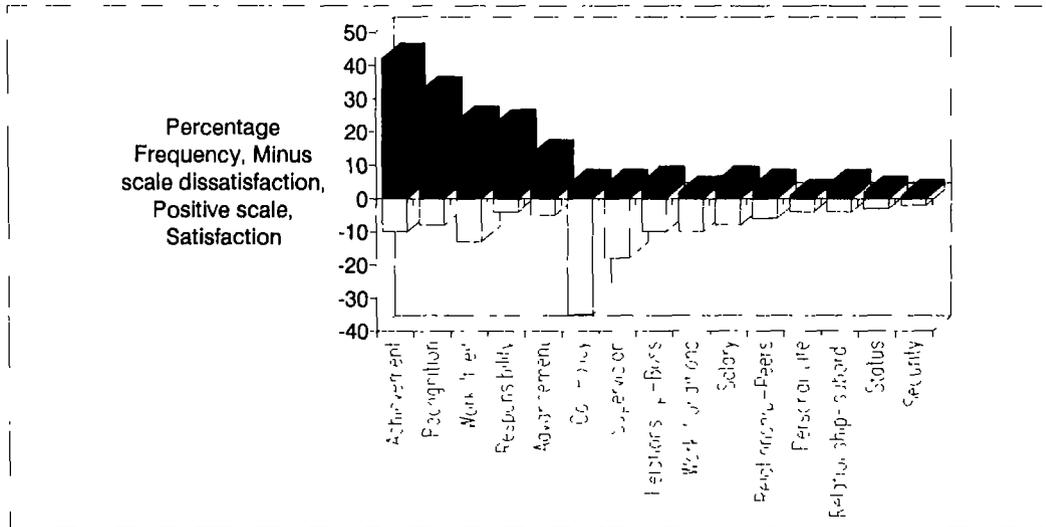
G. Coaching for a Loyal Team

1. Demonstrate the priority given to the team's people needs
2. Show the team's impact on the bottom line
3. Relate to the Person rather than the task
4. Recognize frustration
- . Address frustration promptly
6. Ask for input
7. Collaborate
8. Involve the team in goal setting
9. Provide swift feedback to input
10. Share your spotlight

In this discussion of managing employees on the large Western dairy farm, we have traced changes in the industry that are making effective employee management more critical than ever. The science of human behavior reveals that all people are motivated and motivated to work for a variety of factors. Some of these factors are tremendously powerful; others provide a neutral level of satisfaction. To be effective managers of people, our actions must speak to the motivators and less to the gimmicks many have used in error for so long. The modern dairy manager will need to invest time and money to attain the skills for successful farm management. People management must become a higher priority. The economic value of profit-maximizing dairy nutrition and feeding, for example, is lost if employees do not personally share the objectives of the management.

Clearly, our employees are motivated. We need to understand that motivation and apply the painful lessons of our predecessors and become excellent managers of our motivated employees.

Factors affecting extremes of job attitudes (Herzberg 1968)



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**Removing Barriers
To Communication
In The Dairy Farm
Business**

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Removing Barriers To Communication In The Dairy Farm Business

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Communication plays a major role in employer-employee relationships on dairy farms. It also affects the relationships among family members on the management team. Although effective communication can not guarantee success of a dairy farm business, its absence almost always assures problems. The problems may soon become apparent or they may linger as a gnawing problem for years.

More specifically, communication influences the effectiveness of the hiring and training of employees, motivation of employees, providing daily instructions, performance evaluations and the handling of discipline problems. These are the obvious roles of communication. Communication also affects the willingness of employees to provide useful suggestions. In fact, for employees to evolve from "workers" to "working managers" requires effective communication between supervisors and employees.

Employees typically are hesitant to state their goals, their concerns and their disappointments. Of course, an employee may be a complainer and share views to the point a supervisor silently begs for less "communication." Much more common is the need to better understand what an employee is "really thinking."

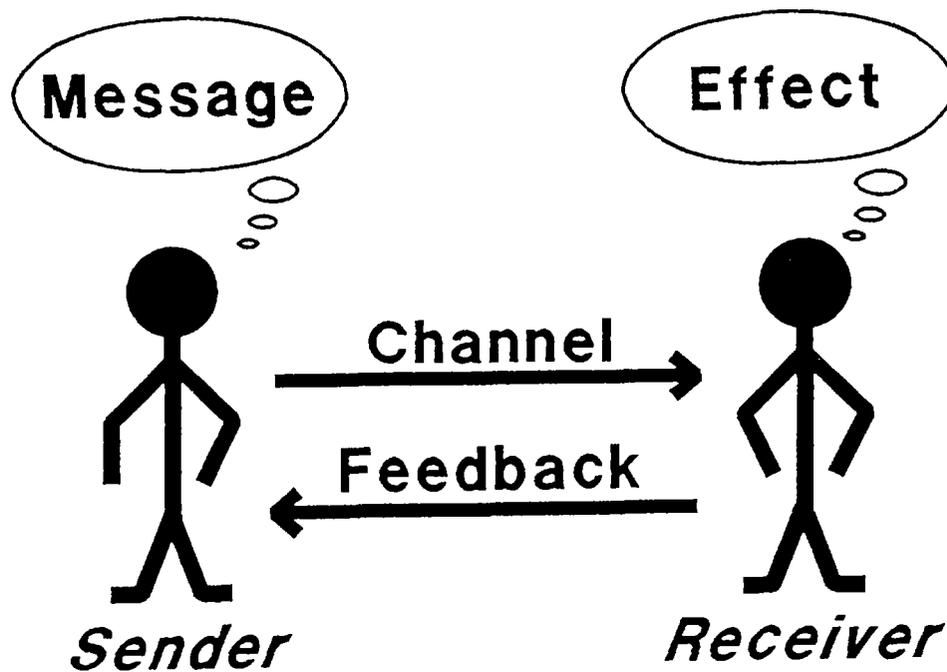
This paper is about improving communication skills. Removing barriers to communication is one of the easiest ways to improve communication. Removing these barriers starts with an understanding of a communication model. One way to improve communication is to think about it. This paper is designed to help dairy farm managers think about their own communication skills and the way communication is done day-to-day back home.

Communication Model

The model in Figure 1 identifies the major components in the communication process. The process starts with a sender who has a message for a receiver. Two or more people are always involved in communication. The sender has the responsibility for the message.

The sender's message travels to the receiver through one or more channels chosen by the sender. The channels may be verbal or non-verbal. They may involve only one of the senses, hearing for example, or they may involve all five of the senses: hearing, sight, touch, smell, and taste. Non-verbal communication, popularly referred to as body language, relies primarily on seeing rather than hearing.

Figure 1. Communication Model



The sending of a message by an appropriate channel to a receiver appears to have completed the communication process or at least the sender's responsibility. Not so! After sending the message, the sender becomes a receiver and the receiver becomes a sender through the process of feedback. Feedback is the receiver's response to the attempt by the sender to send the message. Feedback is the key to determination by the sender of whether or not the message has been received in the intended form. Feedback involves choice of channel by the receiver of the original message. The channel for feedback may be quite different from the original channel chosen by the sender. A puzzled look may be the feedback to what the sender considered a perfectly clear oral instruction.

Effect on the receiver completes the communication process. Effective communication is the original sender having the desired effect on the receiver. Communication at its best minimizes misunderstanding between sender and receiver. The sender can not transplant a message or idea. Ineffective communication means there was no effect on the receiver or the effect was unexpected, undesired and/or unknown to the sender.

This simplified version of a complex process can be a powerful tool for thinking about one's communication skills, diagnosing communication problems and developing plans for improvement of communication. The good news about communication is that improvement is almost always possible. The bad news is that perfection in communication escapes everyone.

Barriers to Communication

Problems with any one of the components of the communication model can become a barrier to communication. These barriers suggest opportunities for improving communication

1. **Muddled messages.** Effective communication starts with a clear message. Contrast these two messages: "Please be here about 7:00 tomorrow morning." "Please be here at 7:00 tomorrow morning." The one word difference makes the first message muddled and the second message clear.

Muddled messages are a barrier to communication because the receiver is left unclear about the intent of the sender. Muddled messages have many causes. The sender may be confused in his or her thinking. The message may be little more than a vague idea. The problem may be semantics, e.g., note this muddled newspaper ad: "Dog for sale. Will eat anything. Especially likes children. Call 888-3599 for more information."

Feedback from the receiver is the best way for a sender to be sure that the message is clear rather than muddled. Clarifying muddled messages is the responsibility of the sender. The sender hoping the receiver will figure out what was really met does little to remove this barrier to communication.

2. **Stereotyping.** Stereotyping causes us to typify a person, a group, an event or a thing on oversimplified conceptions, beliefs, or opinions. Thus, basketball players can be typed as tall, green equipment as better than red equipment, football linemen as dumb, Ford as better than Chevrolet, Vikings as handsome, and people raised on dairy farms as interested in cows. Stereotyping can substitute for thinking, analysis and open mindedness to a new situation.

Stereotyping is a barrier to communication when it causes people to act as if they already know the message that is coming from the sender or worse, as if no message is necessary because "everybody already knows." Both senders and listeners should continuously look for and address thinking, conclusions and actions based on stereotypes.

3. **Wrong channel.** "Good morning." A oral channel for this message is highly appropriate. Writing good morning on a chalk board in the machine shed is less effective than a warm oral greeting. On the other hand, a detailed request to a contractor for construction of a milking parlor should be in writing, i.e., non-oral. A long conversation between a dairy farmer and a contractor about the milking parlor construction, with neither taking notes, surely will result in confusion and misunderstanding. These simple examples illustrate how the wrong channel can be a barrier to communication.

Variation of channels helps the receiver understand the nature and importance of a message. Using a training video on cleaning milking equipment helps new employees grasp the importance placed on quality milk. A written disciplinary warning for tardiness emphasizes to the employee that the problem is serious. A birthday card to an employee's spouse is more sincere than a request to the employee to say "Happy Birthday" to the spouse.

Simple rules for selection of a channel cause more problems than they solve. In choice of a channel, the sender needs to be sensitive to such things as the complexity of the message (good morning versus a construction contract); the consequences of a misunderstanding (medication for a sick animal versus a guess about tomorrow's weather); knowledge, skills and abilities of the receiver (a new employee versus a partner in the business); and immediacy of action to be taken from the message (instructions for this morning's work versus a plan of work for 1992).

4. **Language.** Words are not reality. Words as the sender understands them are combined with the perceptions of those words by the receiver. Language represents only part of the whole. We fill in the rest with perceptions. Trying to understand a foreign language easily demonstrates words not being reality. Being "foreign" is not limited to the language of another country. It can

be the language of another farm. The Gerken house may be where the Browns now live. The green goose may be a trailer painted red long after it was given the name green goose. A brassy day may say much about temperature and little about color.

Each new employee needs to be taught the language of the farm. Until the farm's language is learned, it can be as much a barrier to communication as a foreign language.

5. Lack of feedback. Feedback is the mirror of communication. Feedback mirrors what the sender has sent. Feedback is the receiver sending back to the sender the message as perceived. Without feedback, communication is one-way.

Feedback happens in a variety of ways. Asking a person to repeat what has been said, e.g., repeat instructions, is a very direct way of getting feedback. Feedback may be as subtle as a stare, a puzzled look, a nod, or failure to ask any questions after complicated instructions have been given. Both sender and receiver can play an active role in using feedback to make communication truly two-way.

Feedback should be helpful rather than hurtful. Prompt feedback is more effective than feedback saved up until the "right" moment. Feedback should deal in specifics rather than generalities. Approach feedback as a problem in perception rather than a problem of discovering the facts.

6. Poor listening skills. Listening is difficult. A typical speaker says about 125 words per minute. The typical listener can receive 400-600 words per minute. Thus, about 75 percent of listening time is free time. The free time often sidetracks the listener. The solution is to be an active rather than passive listener.

One important listening skill is to be prepared to listen. Tune out thoughts about other people and other problems. Search for meaning in what the person is saying. A mental outline or summary of key thoughts can be very helpful. Avoid interrupting the speaker. Shut up is a useful listening guideline. Shut up some more is a useful extension of this guideline. Withhold evaluation and judgement until the other person has finished with the message. A premature frown, shaking of the head, or bored look by the listener can easily convince the other person there is no reason to elaborate or try again to communicate his or her excellent idea.

The most important active listening skill is to provide feedback. Ask questions. Nod in agreement. Look the person straight in the eye. Lean forward. Be an animated listener. Focus on what is being said. Repeat key points.

Active listening is particularly important in dealing with an angry person. Encouraging the person to speak, i.e., to vent feelings, is essential to establishing communication with an angry person. Repeat what the person has said. Ask questions to encourage the person to say again what he or she seemed most anxious to say in the first place. An angry person will not start listening until they have "cooled" down. Telling an angry person to "cool" down usually has little value. Getting angry with an angry person just assures that there are now two people not listening to what the other is saying.

7. Interruptions. A dairy farm is a lively place. Few days are routine. Long periods of calm and quiet rarely interrupt the usual hectic pace. In this environment, conversations, meetings, instructions and even casual talk about last night's game are likely to be interrupted. The interruptions may be due to something more pressing, rudeness, lack of privacy for discussion, a drop-in visitor, an emergency, or even the curiosity of someone else wanting to know what two other people are talking about.

Regardless of the cause, interruptions are a barrier to communication. In the extreme, there is a reluctance of employees and family members even to attempt discussion with a manager because of the near certainty that the conversation will be interrupted. Less extreme but nevertheless serious is the problem of incomplete instructions because someone came by with a pressing question.

8. **Physical distractions.** Physical distractions are the physical things that get in the way of communication. Examples of such things include the telephone, a pick-up truck door, a desk, an uncomfortable meeting place, and noise.

These physical distractions are common on dairy farms. If the phone rings, the tendency is to answer it even if the caller is interrupting a very important or even delicate conversation. A supervisor may give instructions from the driver's seat of a pick-up truck. Talking through an open window and down to an employee makes the truck door a barrier. A person sitting behind a desk, especially if sitting in a large chair, talking across the desk is talking from behind a physical barrier. Two people talking facing each other without a desk or truck-door between them have a much more open and personal sense of communication. Uncomfortable meeting places may include a place on the farm that is too hot or too cold. Another example is a meeting room with uncomfortable chairs that soon cause people to want to stand even if it means cutting short the discussion. Noise is a physical distraction simply because it is hard to concentrate on a conversation if hearing is difficult.

Facilitating Communication

In addition to removal of specific barriers to communication, the following general guidelines may also facilitate communication:

1. **Have a positive attitude about communication.** Defensiveness interferes with communication.
2. **Work at improving communication skills.** It takes knowledge and work. The communication model and discussion of barriers to communication provide the necessary knowledge. This increased awareness of the potential for improving communication is the first step to better communication.
3. **Include communication as a skill to be evaluated along with all the other skills in each person's job description.** Help other people improve their communication skills by helping them understand their communication problems.
4. **Make communication goal oriented.** Relational goals come first and pave the way for other goals. When the sender and receiver have a good relationship, they are much more likely to accomplish their communication goals.
5. **Approach communication as a creative process rather than simply part of the chore of working with people.** Experiment with communication alternatives. What works with one person may not work well with another person. Vary channels, listening techniques, and feedback techniques.

6. Accept the reality of miscommunication. The best communicators fail to have perfect communication. They accept miscommunication and work to minimize its negative impacts.

Summary

Communication is at the heart of many interpersonal problems faced by dairy farm managers. Understanding the communication process and then working at improvement provide managers a recipe for becoming more effective communicators. Knowing the common barriers to communication on dairy farms is the first step to minimizing their impact. Managers can reflect on how they are doing and make use of the ideas presented in this paper. When taking stock of how well you are doing as a manager, first ask yourself and others how well you are doing as a communicator.

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NOTES

Production Medicine In Large Dairy Herds

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Production Medicine In Large Dairy Herds

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Dairymen are in business for profit. So are veterinarians. When dairymen and veterinarians work together to manage animal production for profit, their mutually beneficial working relationship is called production medicine.

Dairymen use many professionals to manage their business: accountants, attorneys, nutritionists, service and sales representatives, and veterinarians. But because animal health is so closely associated with animal productivity (especially milk production), the veterinarian is key to the owner/manager of the large dairy enterprise. The dairyman's attitude about how to use veterinary service determines what his veterinarian can do for him.*

Not all dairy cattle veterinarians are qualified to offer production medicine service. The production medicine practitioner sees his objective not necessarily to alleviate pain and suffering of animals, but rather the economic health and well-being of the dairy owner. The dairy animal is a component of a system designed to generate profit. The production medicine veterinarian understands agribusiness principles along with the science of veterinary medicine. He recognizes profit as the dairyman's goal and therefore the object of his service. This is the professional who can best serve progressive and profitable dairymen.

Production Medicine Vs. Preventive Medicine

Production medicine is an outgrowth of preventative medicine but the two are not the same. Preventive medicine can be characterized by reproductive programs in which veterinarians routinely palpate cows for dairymen. Here the palpation serves two purposes: 1) to identify postpartum uterine infection and treat it; 2) to verify pregnancy after insemination. The production medicine approach toward reproduction has a different objective. It is to develop the most profitable means for providing future replacement animals for the dairy herd while maximizing milk production for profitability now. The veterinarian still palpates fresh and bred cows, but does so to monitor people and animal performance rather than identifying which animals require treatment. Monitoring assures that fresh cow care, heat detection, breeding, dry cow nutrition and fresh cow feeding are done correctly to maximize herd reproduction. Reproductive records are also analyzed to assess the fertility status of the herd as a unit and to track the status of individual cows. Programs and staff performance are modified when results don't meet targeted goals.

(*The author recognizes that both woman and men occupy the roles discussed in this chapter (owner/manager, veterinarian and farm staff), but finds the "his/her" format cumbersome. The masculine pronoun is selected since men currently dominate the industry.)

Production medicine is comprehensive herd health. It integrates all areas of health and productivity on the dairy farm. It identifies the different classes of animals on the dairy (replacement heifers, lactating and dry cows, steers and bulls) and devises plans for maximal housing, care and stockmanship of each group. It assesses whether nutritional requirements of all cattle are met to

maximize their production potential and health. Production medicine establishes procedures to detect and treat sick animals but recognizes disease avoidance is as important as proper sick animal treatment. Consequently, appropriate vaccination programs and prophylactic therapy are also part of production medicine programs. A cost-benefit analysis at every step along the way is a major difference between production medicine and simple preventative herd health.

Production medicine focuses on whole herd profitability by maximizing outputs from efficient inputs. Outputs are the expression of each animal's genetic potential. For lactating cows, this is pounds of milk, butterfat and protein per day of lactation. For calves, outputs are rate of gain, livability and disease resistance. For growing heifers, height and weight growth rates. Inputs, on the other hand, are the resources provided for animals to allow them to produce. These include facilities, equipment and feed. Inputs are almost always controlled by people; their stockmanship is a critical input which may either limit or magnify each animals' productivity. In production medicine, the veterinarian assists the owner/manager in determining the most profitable (not necessarily the greatest) animal output from the correct and most efficient use of resource inputs. The distinction between profitable and maximum is key to understanding production medicine. Calves that are fed 1.5 lbs. of dry matter per day grow into bigger, glossier young animals. Calves that are fed 1.2 lbs. of milk replacer on a dry matter basis per day are just as healthy, and start eating calf starter earlier which improves their rumen development. The second option represents a significant savings to the owner-manager, and produces healthy animals with enhanced milk production capacity. The first option places value on maximum output only; the second looks at a larger picture of profitability and represents a production medicine perspective.

Production Medicine And The Large Herd

Production medicine is a concept particularly suited to large herds. In a small herd, the veterinarian works with only one or two people (usually an owner). Success is often achieved because there is keen interest and a direct relationship between the owner's effort and profitability. The large herd, on the other hand, is staffed by more people with diverse interests, different motivation and a wide range of stockmanship capability. Production medicine provides a comprehensive plan to educate, motivate and monitor stockmen and herdsman. Such a plan is essential for smooth day-to-day operation of the large dairy, and places the veterinarian in a position to be most useful for maximizing dairy profits. In production medicine, the owner/manager and veterinarian each have distinct responsibilities as each relates to farm staff. These need to be clear to both parties so that accountability for success or failure of people or programs is properly identified.

A word of caution: large dairy herds reflect the people who work them, their faults and weaknesses as well as their skills and strengths. The dairy owner/manager and the veterinarian must take into account the range of abilities for understanding and performing when devising programs for people to implement. They must be kept simple if there is a chance that even basic dairy fundamentals will not be achieved. Without the fundamental practices for milking hygiene, animal health and nutrition in place, nothing else can succeed.

Structure And Management Of The Large Dairy Herd

The large dairy enterprise consists of several specialized subunits, each with a particular husbandry and management requirement. A typical division of a dairy's subunits and the farm personnel responsible for them are illustrated in Figure 1.

This specialized management structure groups specific responsibilities for each area and designates the person or team charged with those responsibilities. Besides providing for the smooth run-

ning of an operation, this management system develops accountability. That is, the owner/manager can assign specific responsibilities and performance standards to the person in charge of each unit. The level of performance of the whole dairy is a measure of the combined performance of each of the units.

Typically the owner/manager directs the day-to-day activities of his employees as well as making daily and long-term decisions for the operation. The herdsman may be accountable only for daily animal care and stockmanship, or may be given some management responsibility over milkers, assistants and others. Similarly, the feed manager, replacement herd manager, utility foreman and office superintendent may be assigned specific technical functions or may also supervise any number of farm staff.

The production medicine veterinarian works with farm personnel on large dairies on three levels: 1) directly with the owner/manager, 2) with unit managers, and 3) cow-side staff (Figure 2). Some version of this management format has to exist in order for the large dairy operation to function efficiently. The successful owner/manager can describe his management scheme clearly, employ the right people in key management positions, involve his veterinarian in the appropriate roles and explain to each employee the specific role he or she plays on the dairy's operation. The astute veterinarian will recognize that he has responsibilities to different levels of management, and that the appropriate responses to individual needs (animal and people) will vary depending on management structure and style.

The owner/manager orchestrates the communication and teamwork among key management people. As an example of this process, consider the movement of springing heifers to the close-up pen (replacement herd foreman responsibility). The head count in the close-up pen is now changed (herdsman responsibility) and necessitates a change in the amount of feed to that group of cattle (feed manager responsibility). The owner/manager is responsible for devising communication systems to integrate these activities. Similar coordinated efforts are required to respond to output problems. If several instances of displaced abomasums occur in a week (veterinarian responsibility) and simultaneously production in fresh cows is below targeted standards on test day (herdsman responsibility), these may be clues that addition of a feed component (feeder responsibility) to the fresh cow ration was done suddenly rather than changed gradually over several days (feeder responsibility). Systems exist not only to coordinate everyone's efforts, but to maintain a level of efficiency which maximizes output to the level of greatest profit.

Personnel Management Principles To Maximize Animal Outputs

When the management structure for the dairy is clear, farm staff can be organized to maximize their productivity and that of the animals in their care. The production medicine veterinarian works closely with the owner/manager to apply four basic management principles adapted from other industries. The object is always to maximize performance from the people and animal resources of the dairy.

1. Goal setting — Goals established by the owner/manager for milk production performance are generally meaningless to the cowside farm staff. Rather, specific goals for each unit of the dairy need to be established. When specific goals for each unit are set and achieved, the grand goal for the entire enterprise (whether 24,000 lb. rolling herd average or maximum profitability) is also achieved.

Since goals for output performance of each unit necessarily include maximum health performance, the veterinarian should be involved in setting goals. Ideally, the owner and veterinarian

establish a tentative list of goals for each unit and then solicit feedback from the unit manager. His contributions not only add a touch of reality to the expectations, but it gives the unit manager a sense of ownership in the goals for output expectations from him and the animals he manages. Goals established this way provide farm staff with a sense of job satisfaction when targets are achieved. Figure 3 provides examples of specific goals that could be established for individual units of the dairy.

2. Establishing programs and training staff — Farm staff need a plan to accomplish goals. The plan — a program — is a system that directs people to perform specific activities on a routine basis for the maximum benefit of the animals in their care. Programs are very specific action plans, such as the following:

Colostrum Delivery Program

1. Immediately after a calf is born, remove one 2-quart bottle of colostrum from the refrigerator and warm it in a pail of hot water. 2. In no less than 1 hour, transport the calf to the next unoccupied calf barn pen. 3. Immediately dip the navel with iodine. 4. Feed the calf 1 bottle of colostrum by sucking from the nipple bottle. 5. If the calf fails to suckle within 10 minutes, use an esophageal feeder to feed the calf 2 quarts of colostrum. 6. Apply an ID tag to the calf's left ear immediately after colostrum feeding. 7. Record all calving and identification information in the fresh cow log after caring for the calf.

This is a very specific action plan for feeding colostrum to newborn calves. When executed properly it will accomplish its objective: to maximize colostrum antibody levels in the newborn calf. When done consistently, EVERY calf will have adequate antibody levels. It is specific: there is no interpretation required for knowing how or what to do. It does not deal with how or where to get the colostrum — that is covered in the Colostrum Collection Program. Nor does it deal with subsequent feedings, which is yet another program.

A word of caution: a program combines a PRINCIPLE and a PRACTICE. A principle is an unarguable fact of dairy management; a practice is one of a variety of methods to implement the principle. For example, a milking routine for a mastitis control program is based on the PRINCIPLE of milking clean, dry teats. The PRACTICE to accomplish this may vary: pre-dip teats; wash teats and dry them with a paper towel; avoid any use of water and milk dry teats or use holding pen sprays followed by wiping teats with cloth towels. One of several practices may be chosen to be part of the program. This is the art of successful management — knowing the principles, then knowing how to select from a variety of practices those most appropriate for a particular dairy operation. Programs should be developed for each activity of the dairy unit that affects the output of that unit. The owner/manager and unit manager should jointly author the programs for his area; that assures realistic practices appropriate for the particular staff involved and maintains the owner's priority on profit. The veterinarian is the best resource to identify the animal health principle involved. He can also draw on experiences with other clients to advise which practices may be most effective and suited to that particular dairy.

Dairy employee performance improves when staff know not only what to do, but also why to do it. The veterinarian in a production medicine mode provides the how and why training through demonstrations, one-on-one sessions and group meetings to farm staff. Because programs are only action plans, they can't accomplish goals until they're implemented. Training dairy staff is as crucial as developing the basic program.

3. Monitoring performance — The owner/manager must determine whether the programs are

being implemented by his staff to achieve the output target (i.e., "You can't manage it if you can't measure it.") Monitoring staff performance requires records that measure output. Wherever possible, the records should distinguish between animal output and people performance. While most dairymen use handwritten or computer-generated records on the farm, some areas of the dairy may not be monitored adequately. Under a production medicine agreement, the owner/manager and veterinarian can develop records where none exist, and customize those that are routinely maintained or provided to the dairy (e.g., DHIA) to suit the analysis required. Figure 4 illustrates a variety of records that may be used to monitor a dairy fertility program, as an example.

Whenever data is entered into records, it should include costs and expense/income information when possible. At the least, cost-benefit analyses can help to evaluate effectiveness of particular programs or treatments. Sophisticated bookkeeping systems can integrate these sub-unit analyses with information used to generate periodic profit/loss statements, and generate more precise financial information.

Once records are designed and used in each unit of the dairy, they should be summarized and evaluated periodically. Although time consuming, this is a crucial part of production medicine management. Computer generated reports can be assimilated faster than hand-kept records and lend themselves to graphic display. Graphics bring records to life and are generally preferred by both the owner/manager and staff of large dairies. The veterinarian is usually instrumental in interpreting records, particularly when determining whether animals or staff are responsible for deviations from normal. If, for example, heat detection performance in fresh cows and heifers is unacceptably low, palpation of the reproductive tracts might reveal static ovaries and poor uterine involution (a cow or nutritional problem). On the other hand, palpation might also indicate normal cycling ovaries and good uterine health (thus pointing to personnel failing to observe heat activity, a people performance problem).

Results of record analysis should be compared to the goals established by the owner/manager and unit managers. When records are analyzed jointly by the owner/manager, veterinarian and farm staff, there is more credibility and ownership of the results by the farm staff.

4. Reacting and readjusting performance — The owner/manager has sole responsibility to react in response to the results of periodic record analysis. The veterinarian can play a vital role in developing a reaction strategy with the owner/manager, but he must remember that the job of a production medicine veterinarian is to manage herd health — not the herd or the people employed on the dairy.

Reaction strategy aims at adjusting animal and/or people performance and takes one of two forms: positive response, and reaffirmation of the goals achieved, or negative response with appropriate redirection of efforts and program changes toward goal achievement.

When output goals are achieved, animals in that dairy unit have been well tended, because only then will maximum animal output occur over the long term. The farm staff responsible for achieving those goals require recognition. Acknowledgement of a job well done (positive reinforcement) is the key to future performance. It may take many forms (aside from monetary) but an owner who takes for granted the people who performed well jeopardizes his team. When satisfactory performance goes unrecognized, attitudes of "Why should I care — the boss doesn't" quickly develop. Effective owners/managers make a point of catching their people doing the right thing — and commenting on it.

Underachievement may force changes in a program if poor animal output is to blame. If unacceptable people performance is the cause of underachievement, however, the response should be immediate, specific, definite and conclude with a positive reaffirmation of the goal and the per-

son. In a case of low conception rate due to poor insemination technique, for example, a manager could approach his herdsman like this:

Immediate

"John, we just got done looking at last month's first service conception rates and there seems to be a problem."

Specific

"Your conception rate was 23%, while Joe's was 48%. Doc says most of his other clients are around 45-50%."

Definite

"John, the targets we all agreed to this fall were a 50% conception rate. Last year's records showed that you were above 50% for several months."

Positive Reinforcement

"Doc feels that some of the problem may be a bad habit you've developed in your semen handling technique. John, we know you can do well if we can get some glitches worked out. I'd like you and Doc to work together with a reproductive tract that he has to review your techniques. I'm sure you'll get back to your old performance levels again."

Choosing the appropriate reaction strategy is often difficult but a straightforward, businesslike approach is most effective. Managing cows and people at the same time is an art; successful dairy owner/managers integrate their cow sense with keen insight into interpersonal relations when handling their staff. Production medicine veterinarians observe the lines of authority to ensure that supervisors take ownership for problem solving in their units and that appropriate re-training and monitoring takes place.

Nutrition And Animal Productivity

The emphasis production medicine places on profitability demands a brief discussion of nutrition. Feed costs generally account for 50% of total annual expenses on large dairies and proper nutrition is crucial to dairy cattle productivity. Controlling feed costs and deciding what and how much to feed can significantly alter total annual expenses and therefore profit from the dairy.

Feed rations must be balanced to meet both nutritional maintenance and production requirements. Nutritional balancing is essential for maximal milk flow, butterfat production, healthy body condition and appropriate growth rates.

Because balancing rations simply for protein, energy and macro elements is no longer sufficient for large successful operations, dairymen need to rely on professional expertise. Trained and experienced nutritionists can balance the ration for micro elements, use by-pass protein and by-pass fat, all while working with the most cost-effective and available feeds. The most valuable nutritionists have, in addition to advanced training and experience feeding dairy cattle, support services available (e.g., laboratory testing of feeds for nutrient analysis and micro-nutrient mixing facilities), and a finger on the pulse of commodity and feed prices. Dairymen can choose a professional nutritionist, a feed company nutritionist or veterinarian who demonstrates the ability to do nutritional consulting. In the first two cases, the veterinarian offering production medicine services is responsible for developing an effective working relationship with the nutritionist because animal health and nutrition are so closely related. A production medicine veterinarian would, for example, tabulate body condition scores, manure consistency and incidence of displaced abomasum and digestive upsets in order to assist the nutritionist in reformulating rations or troubleshooting production problems.

Balancing rations, proper feed mixing and feedbunk management are three crucial areas in feeding cows. The owner/manager of a large herd works with the veterinarian and/or nutritionist to devise specific feeding programs for the feed team. Monitoring animal output and people performance in this program is critical for dairy profitability. Analysis of the feeding program should include calculating actual feed intake routinely (weighing what is fed minus what is left uneaten) to determine if “what is formulated is what is mixed is what is eaten.”

Summary

Management causes problems by failing to establish clear requirements, and it perpetuates those problems by not setting and maintaining a clear performance standard. Modern large dairy herds are agribusiness enterprises that must adopt commonly accepted management principles from other industries for their operations. When they do, production medicine is the logical approach for incorporating professional veterinary services into the operation. A qualified veterinarian and the dairy owner/manager work together to maximize outputs and profitability by:

1. Organizing a management scheme.
2. Establishing performance goals for each subunit of the dairy.
3. Providing farm staff with programs and resources to achieve the goals.
4. Monitoring animal and people performance.
5. Responding to performance assessments appropriately.

Production medicine is a professionally rewarding service for the dairy cattle practitioner and an invaluable management asset to the dairy owner/manager who understands and uses it effectively.

Figure 1: Management Scheme of a Typical Large Dairy.

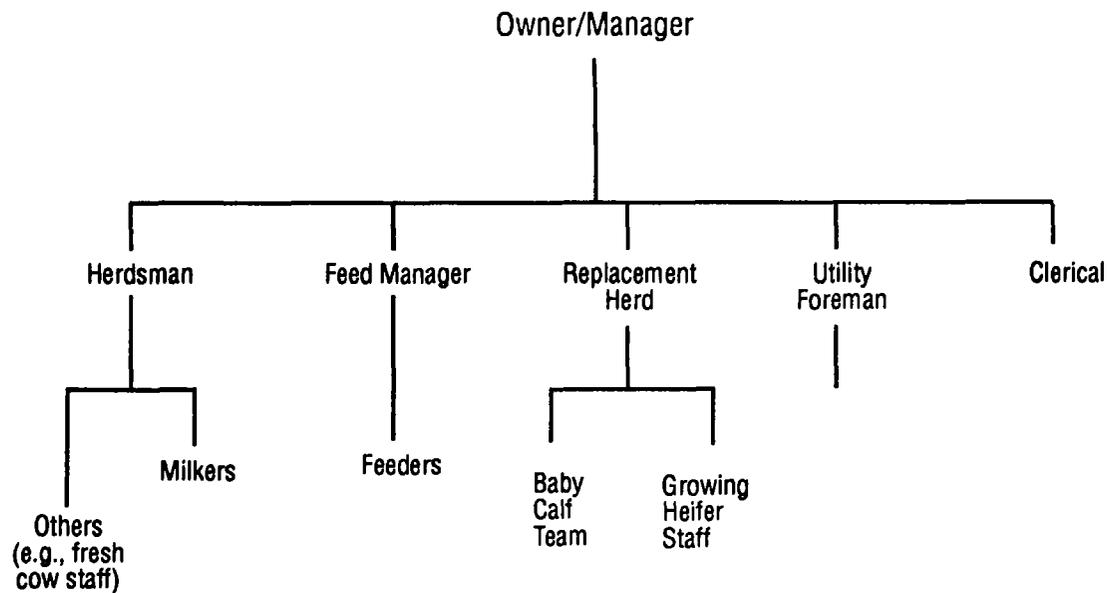
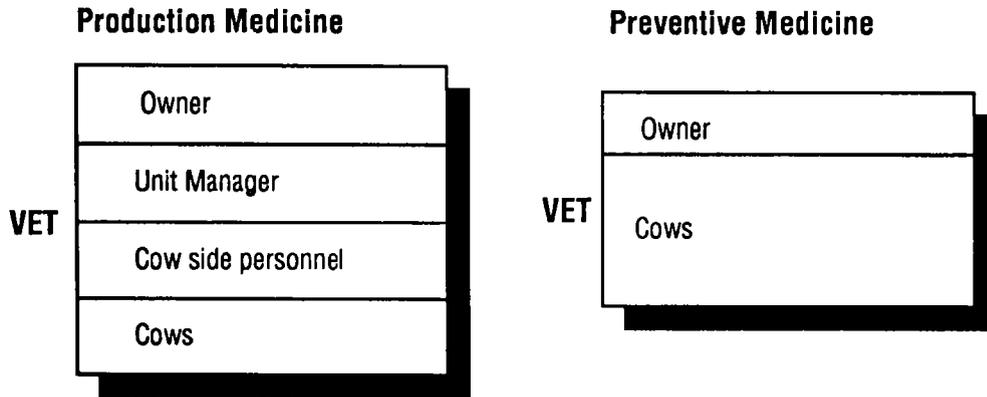


Figure 2: Veterinary Involvement with the Large Dairy.



Although both approaches demand veterinary skills, the production medicine mode also requires a wide range of communication skills in order to work effectively with each person on the dairy.

Figure 3: Example Goals for Large Dairy Farm Units. (a)

1. Fresh Cow Health (herdsman)	
difficult or assisted calvings	<15% of cows
live birth rate	<25% of heifers
retain fetal membrane	>95% of births
metritis	<10% of calvings
	<20% of calvings at 15 days
2. Fertility (herdsman)	
heat detection pregnancy % *	>85% of cows palpated
24-day trial **	>90% of cows evaluated month
cystic ovaries	<12% annually
pyometria	<0.5% annually
abortions	<10% annually
conceptions to 1st service	>50% in winter months
	>35% in summer months
calving interval	<13 months
services per conception	<2.0
DIM to first breeding	<70 days
3. Cow Health (herdsman/milkers)	
mastitis/milk quality	<200,000 ESCC in bulk tank
	<5,000 SPC in bulk tank
	<0.5% of milking cows withheld for mastitis treatment
	<7 days treatment and w/h per mastitis case
milk fever	<3% of calvings
ketosis	<3% of calvings
displaced abomassum	<0.5% of calvings
mortality	<3% annually

4. Calf Health (calf foreman)

mortality	<2% annually
scours	<5% annually
pneumonia	<5% annually
treatment cost	<\$12.00/calf

5. Young Stock (growing heifer foreman)

mortality	<1% annually
growth rates	standard height/weight charts

6. Milk production (everyone)

daily production	>70 #/cow/day
daily fat	>3.5 avg./day
rolling herd average	>22,000 lbs. annually
peak milk flow	
-heifers:	>80 lbs
- 2nd lactation:	>100 lbs
- 3+ lactation:	>110 lbs
days in milk	150 days

(a) These figures are offered as examples only and are not complete or accurate for all situations.

(*: Pregnancy percentages = # of cows palpated pg divided by total # of cows presented for pg examination.)

(**: 24-day trial = # of fresh cows bred within 24 days divided by # of cows identified as eligible to breed over that same 24 day period.)

Feed Additives

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Feed Additives

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Feed additives are feed ingredients that produce a desirable animal response in a non-nutrient role (a nutrient role would be providing protein or mineral requirements). Additives can lead to the following responses:

- Increased milk yield (peak milk and/or milk persistency)
- Increase in milk components (protein and/or fat)
- Increased dry matter intake
- Maintain a desirable rumen pH
- Stimulate rumen microbial synthesis of protein and/or volatile fatty acid (VFA) production
- Increased rate of passage or flow of nutrients out of the rumen
- Improved fiber digestion in the rumen
- Stabilize rumen environment
- Improve growth (gain and/or feed efficiency conversion)
- Minimize weight loss
- Reduce heat stress effects
- Improve health (such as less ketosis, reduced acidosis, or improved response)

Economics or profitability is a key factor when deciding if an additive should be used. If milk improvement is the observed response, Table 1 can be used to determine breakeven point. For example, if an additive costs six cents a day and milk is priced at \$10 per cwt, every cow must increase milk yield .6 pound per cow to cover the additive cost. An additive should return two dollars for every one invested to cover non responding cows and variable responses under field conditions.

Research is essential to critically determine if a measured response can be repeated in the field. Studies must be conducted under controlled and unbiased conditions, be statistically analyzed, and completed under conditions that are similar to field situations.

Results obtained on individual farms are the economic payoff for dairy managers. When selecting an additive, decide which measurements can be used to evaluate success (peak milk, milk persistency, milk component changes, reproduction shifts, somatic cell count changes, dry matter intake, heifer growth charts, body condition score, or herd health profiles).

Feed additives are not a must for high milk production and economic success. Table 2 compares the use of common feed additives in high producing herds in 1983 and 1992. Interest in feed additives will continue and will be influenced by new research results, advertising, and profit margins. Table 3 outlines feed additives in six categories that will allow dairy managers, consultants, feed company personnel, and veterinarians to decide if an additive should be used. Current status is classified as recommended (include as needed), experimental (additional research is needed), evaluative (monitor under specific situations), or not recommended (lacks economic response to currently use).

Table 1: Required increase in milk yield to recover various additive costs with different milk prices.

Additive Cost (\$/cow/day)	Milk Price (\$/cwt)		
	10	12	14
	—— lbs milk/cow/day ——		
.02	.2	.2	.1
.06	.6	.5	.4
.10	1.0	.8	.7
.30	3.0	2.5	2.1

Table 2: Feed additives used in diets fed to high producing herds in 1992 compared to 1983.

Additive	1992	1983
	% used	% used
Sodium bicarbonate	75	70
Magnesium oxide	66	NA
Yeast/Yeast culture	51	17
Niacin	38	16
Zinc methionine	48	NA

Table 3: Current status of common feed additives for dairy cattle.

ANHYDROUS AMMONIA

1. Function: Sources of non-protein nitrogen, extend fermentation in silage, reduce mold growth, improve bunk life at feeding time, and increase fiber digestibility.
2. Level: Corn silage = 8 lb per wet ton
 Legume/grass = 1% D.M.
 Straw/low quality forage = 2 to 3% D.M.
3. Cost: Depends on level.
4. Benefit to Cost Ratio: Not available.
5. Feeding Strategy: Apply to silage prior to ensiling, during the baling of hay, or under plastic cover to treat straw.
6. Status: Recommended.

ANIONIC SALTS

1. Function: Cause the diet to be more acidic, increasing blood calcium levels by stimulating bone mobilization of calcium and calcium absorption from the small intestine.
2. Level: 100g ammonium chloride 100g magnesium sulfate.
3. Cost: 20¢ to 25¢ per day.
4. Benefit to Cost Ratio: 10:1.
5. Feeding strategy: Feed to dry cows two to three weeks before calving. Adjust dietary calcium levels up to 100 to 150g per day.
6. Status: Recommended.

ASPERGILLUS ORYZAE (Amaferm brand name)

1. Function: Stimulate fiber digesting bacteria, and stabilize rumen pH, and reduce heat stress.
2. Level: 3g per day.
3. Cost: 5¢ per day.
4. Cost to Benefit Ratio: Not available.
5. Feeding Strategy: High grain diets, low rumen pH conditions, and under heat stress.
6. Status: Experimental.

BETA-CAROTENE

1. Function: Improve reproductive performance, immune response, and mastitis control.
2. Level: 200 to 300 mg per day.
3. Cost: 30¢ per day.
4. Benefit to Cost Ratio: Not available.
5. Feeding Strategy: In early lactation and during mastitis-prone time periods.
6. Status: Not recommended.

CHOLINE

1. Function: A methyl donor used to minimize fatty liver formation and to improve neurotransmission.
2. Level: 30g per day.
3. Cost: 10¢ per cow.
4. Benefit to Cost Ratio: Not available.
5. Feeding Strategy: Feed dry cows two weeks prepartum and to cows experiencing ketosis and weight loss.
6. Status: Not recommended until rumen protected.

DECOQUINATE (Deccox brand name)

1. Function: Prevent and control coccidiosis in calves.
2. Level: .5 mg/2.2 lb (kg) of B.W.
3. Cost: 2¢ per day.
4. Benefit to Cost Ratio: Favorable.
5. Feeding Strategy: Add to liquid diet and/or calf starter.
6. Status: Recommended.

LASALOCID (Bovatec brand name)

1. Function: An ionophore for calves and heifers only which shifts rumen volatile fatty acid patterns, lower methane, production, improves feed efficiency, and prevents coccidiosis in calves.
2. Level: 60 to 200 mg per heifer.
3. Cost: 1¢ to 2¢ per heifer per day.
4. Benefit to Cost Ratio: 8:1.
5. Feeding Strategy: To young calves (coccidiosis prevention) and growing heifers (growth and feed use improvement).
6. Status: Recommended.

MAGNESIUM OXIDE

1. Function: Alkalizer (raises rumen pH) and increases uptake of blood metabolites by the mammary gland raising fat test.
2. Level: .1 to .15 pound per day.
3. Cost: 2¢ per day.
4. Benefit to Cost Ratio: Favorable.

5. Feeding Strategy: With buffers.
6. Status: Recommended.

METHIONINE HYDROXY ANALOGUE

1. Function: Minimize fatty liver formation, control ketosis, and improve milk fat test.
2. Level: 30 g.
3. Cost: 10¢.
4. Benefit to Cost Ratio: 2:1.
5. Feeding Strategy: Feed to cows in early lactation receiving high levels of concentrate and limited dietary protein.
6. Recommendation: Not recommended.

MONENSIN (Rumensin brand name)

1. Function: An ionophore for calves and heifers only which shifts rumen fermentation increasing feed efficiency and prevents coccidiosis.
2. Level: 50 to 200 mg per heifer.
3. Cost: 1¢ to 2¢ per heifer per day.
4. Benefit to Cost Ratio: 8:1.
5. Feeding Strategy: To growing heifers (over 400 lb) and prevent coccidiosis.
6. Status: Recommended.

NIACIN (B3, nicotinic acid, and nicotinamide)

1. Function: Coenzyme system in biological reactions, improve energy balance in early lactation cows, minimize ketosis, and stimulate rumen protozoa.
2. Level: 6g per cow (preventive) 12g per cow (treatment).
3. Cost: 6¢ to 12¢ per day.
4. Benefit to Cost Ratio: 6:1.
5. Feeding Strategy: High producing cows in negative energy balance, heavy dry cows, and ketotic-prone cows fed two weeks prepartum to peak dry matter intake (10-12 weeks postpartum).
6. Status: Recommended.

PROBIOTICS (Bacterial direct-fed microbes)

1. Function: Produce metabolic compounds that destroy undesirable organism, provide enzymes improving nutrient availability, or detoxify harmful metabolites.
2. Level: Not clearly defined.
3. Cost: 3¢ to 18¢ per day
4. Benefit to Cost Ratio: Not available.
5. Feeding Strategy: To cows at calving to balance host animal's digestive tract during stressful or disease conditions and to calves on liquid diet to stimulate calf starter intake.
6. Status: Experimental.

PROPIONIC ACID

1. Function: Mold inhibitor and preservative for high moisture corn, wet hay, and haylage.
2. Level: .5 to 1.5 percent (depends on moisture level).
3. Cost: 50-60¢ per pound.
4. Benefit to Cost Ratio: Favorable.
5. Feeding Strategy: Apply to forage or grain prior to storage or ensiling.
6. Status: Recommended.

SILAGE BACTERIAL INOCULANTS

1. Function: To stimulate silage fermentation reducing dry matter loss, decreasing ensiling temperature, and increasing VFA production.
2. Level: 100,000 organisms per gram of wet silage or 90 billion per ton (common bacteria inoculants include *Lactobacillus plantarum*, *Lactobacillus acidilacti*, *Pediococcus cerevisiae*, *Pediococcus pentacoccus*, and *Streptococcus faecium*).
3. Cost: \$.50 to \$2 per pound.
4. Benefit to Cost Ratio: 8:1.
5. Feeding Strategy: Apply to wet silages (over 60% moisture), first and last cutting (due to natural low bacteria levels), and poor fermentation environment.
6. Status: Evaluative.

SILAGE ENZYMATIC INOCULANTS

1. Function: To digest plant cell walls which can be used by lactic-acid bacteria lowering silage pH and to improve the rate or extent of forage digestibility.
2. Level: Not clearly defined.
3. Cost: Variable.
4. Benefit to Cost Ratio: Not available.
5. Feeding Strategy: Ensilage inoculants (celluloses, pectinases, hemicellulases, xylanases, and amylases) at storage. Protease enzymes are questionable. Wetter silages may benefit more.
6. Status: Experimental.

SODIUM BENTONITE

1. Function: A clay mineral used as a binder, shifts VFA patterns, slows rate of passage, and exchanges mineral ions.
2. Level: 1 to 1 1/2 pound per day (rumen effect).
3. Cost: 4¢ to 6¢.
4. Benefit to Cost Ratio: Not available.
5. Feeding Strategy: With high grain diets, loose stool conditions, low fat test, and dirt eating.
6. Status: Evaluative.

SODIUM BICARBONATE/SODIUM SESQUICARBONATE (BUFFER)

1. Function: Increase dry matter intake and maintain rumen pH.
2. Level: .75% of total ration dry matter intake.
3. Cost: 5¢ to 6¢ per day.
4. Benefit to Cost Ratio: 4:1.
5. Feeding Strategy: Feed 120 days postpartum and with diets high in corn silage (over 50%), wet rations (over 45% moisture), lower fiber rations (<19% ADF), little hay <5 lb), finely chopped forage, pelleted grain, slug feeding, and heat stress conditions.
6. Status: Recommended.

UREA

1. Function: Source of non-protein nitrogen, extend corn silage fermentation, and improve bunk life at feeding .
2. Level: 10 pounds per ton of wet corn silage.
3. Cost: 13¢ per pound.
4. Benefit to Cost Ratio: 3:1.
5. Feeding strategy: Apply at ensiling.
6. Status: Recommended.

YEAST CULTURE

1. Function: Stimulate fiber digesting bacteria, stabilize rumen environment, and utilize lactic acid.
2. Level: 10 to 120 g (1/4 lb) depending on yeast culture concentration (source).
3. Cost: 6¢ per day.
4. Cost to Benefit Ratio: 4:1.
5. Feeding Strategy: Two weeks prepartum to two weeks postpartum and during off-feed conditions and stress.
6. Status: Recommended.

ZINC METHIONINE (Zinpro brand name)

1. Function: Improve immune response, harden hooves, and lower somatic cell counts.
2. Level: 4.5g per day (Zinpro 40 product).
3. Cost: 2¢ per cow.
4. Benefit to Cost Ratio: 14:1.
5. Feeding Strategy: To cows experiencing foot disorders.
6. Status: Recommended.

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Economics Of Forage Quality

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Economics Of Forage Quality

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The three forages most commonly fed to dairy cattle in the western United States are alfalfa hay, corn silage, and winter cereal silages. Therefore, this discussion will concentrate on those forages. Each has unique characteristics that affect its nutritional and economic value in dairy rations, so they will be discussed separately

Alfalfa

Dairy producers and alfalfa hay growers are well aware of the tremendous difference in feeding value between alfalfa harvested at an immature stage compared with a more mature stage (e.g., bud-stage compared with mid- or full-bloom alfalfa). An alfalfa quality testing program has been in place in California for over 30 years based on research at UC Davis in the 1950's (Meyer and Jones, 1962) that showed greater digestibility, faster weight gains and higher milk production from cattle fed alfalfa harvested at an immature stage. Subsequently, similar forage testing programs were developed in many other states. Maturity of alfalfa is closely related to its fiber content; as stage of maturity increases, so does its fiber content, and digestibility of the plant decreases. Laboratories use tabular values to predict Total Digestible Nutrients (TDN) and Net Energy for Lactation (NEL) values for an alfalfa sample based on its fiber content. These values in turn are used for determining relative economic values of different lots of alfalfa hay, and for formulation of diets for animals consuming the alfalfa.

High-quality alfalfa must be nutritious and palatable and must be preserved in a manner that will retain these characteristics. Digestibility alone cannot characterize alfalfa quality. To be of greatest value, alfalfa must also be consumed at the highest level possible. High-quality alfalfa is consumed in greater quantities than low-quality alfalfa, thus magnifying its nutritional and economic benefits.

Visual factors such as stage of maturity, leafiness, foreign material, condition and odor, and green color, have been used to estimate alfalfa digestibility and palatability. A review of these factors and descriptions of chemical tests to estimate alfalfa quality based on its fiber content are contained in a University of California Cooperative Extension publication: "Testing Alfalfa for its Feeding Value" (Bath and Marble, 1989). The publication also contains tables that can be used to estimate relative economic values of alfalfa at various fiber and moisture contents. However, relative economic values in the bulletin are based on digestibility as estimated from fiber content and do not take palatability and consumption into consideration.

A computer program for formulation and analysis of dairy cattle rations called PCDAIRY (Bath and Strasser, 1990) can be used to determine the relative economic values of various lots of alfalfa based on their palatability and consumption, as well as nutritional values. The program requires a formulated ration to fulfill all nutritional requirements (National Research Council, 1989) within feed dry matter intake limits based on cow size and level of milk production. Therefore, the relative economic values determined with PCDAIRY are more accurate than those based only on digestibility.

To illustrate the use of the computer program, a comparison was made of three lots of alfalfa hay with varying fiber contents. Hay lots were characterized by their acid detergent fiber (ADF) contents, but modified crude fiber (MCF) could be used as well. The three lots contained 28%, 32%, and 37% ADF, respectively, which correspond to total digestible nutrient (TDN) levels of 55%, 52%, and 49% TDN at 90% dry matter. For comparison purposes, the lot with 32% ADF was specified to be worth \$120 per ton on the open market, and all three lots contained 90% dry matter. Other feedstuffs available for the rations and their prices were:

Feedstuff	\$ per ton	Feedstuff	\$ per ton
Almond Hulls	80	Whole Cottonseed	180
Barley Grain	160	Dicalcium Phosphate	500
Beet Pulp	150	Limestone	100
Corn Grain 160		Molasses	90
Cottonseed Meal	200	Rice Bran	140
Wheat Millrun	150		

Rations were formulated for four levels of milk yields with each of the three hay lots. A summary of milk yields, feed costs, and income over feed costs (IOFC) with the standard hay (32% ADF and \$120/ton) is shown in Table 1. Daily feed costs increased from \$2.88 per cow for 46 lb of milk to \$4.60 per cow for 104 lb of milk. However, daily IOFC increased even faster from \$3.10 per cow for 46 lb of milk to \$8.88 per cow for 104 lb of milk, illustrating the increased profitability of high-producing cows.

Table 1: Milk yields, feed costs, and income over feed costs of cows fed alfalfa hay with 32% ADF.

	Milk Production Group			
	Low	Medium	High	Super
Milk (lb/day)	46	66	86	104
Alfalfa hay (\$/ton)	\$120	\$120	\$120	\$120
Feed costs (\$/day)	\$2.88	\$3.50	\$4.16	\$4.60
IOFC (\$/day)*	\$3.10	\$5.08	\$7.02	\$8.88

*IOFC = Income over feed costs.

In a second set of computer formulations, the price of alfalfa hay with 28% ADF was allowed to vary so that IOFC would be the same as it was for the previous rations using alfalfa hay with 32% ADF at \$120 per ton. Results are shown in Table 2. The relative value of alfalfa with 28% ADF varied from \$127 per ton for the low-yielding cows to \$139 per ton for the high-producers, or an increased value of \$7 to \$19 per ton.

Table 2: Milk yields, relative economic values of alfalfa hay, feed costs, and income over feed costs of cows fed alfalfa hay with 28% ADF.

	Milk Production Group			
	Low	Medium	High	Super
Milk (lb/day)	46	66	86	106
Alfalfa (\$/ton)	\$127	\$127	\$131	\$139
Feed costs (\$/day)	\$2.88	\$3.50	\$4.16	\$4.90
IOFC (\$/day)*	\$3.10	\$5.08	\$7.0	\$8.88

*IOFC = Income over feed costs.

In a third set of computer formulations, the price of alfalfa hay with 37% ADF was allowed to vary so that IOFC would be the same as it was for the standard hay (32% ADF and \$120 per ton). The results are shown in Table 3. The relative value of alfalfa with 37% ADF was \$111 per ton for the low-yielding cows, but declined to a negative value for the high-producers. In fact, the computer could not formulate a balanced ration for cows producing more than 89 lb of milk using the alfalfa with 37% ADF, even if large amounts of grain concentrates were fed. This illustrates the well-known fact that high-producing cows must be fed high-quality forages as well as liberal amounts of grain concentrates in order to maintain high milk yields.

Table 3: Milk yields, relative economic values of alfalfa hay, feed costs, and income over feed costs of cows fed alfalfa hay with 37% ADF.

Milk Production Group	Low	Medium	High	Super
Milk (lb/day)	46	66	81	89
Alfalfa (\$/ton)	\$111	\$108	\$81	-0-
Feed costs (\$/day)	\$2.88	\$3.50	\$3.47	\$2.93
IOFC (\$/day)*	\$3.10	\$5.08	\$7.02	\$8.61

*IOFC = Income over feed costs.

The relative values of the three hay lots at the four levels of milk production are summarized in Table 4. Assuming a price of \$120 per ton for the alfalfa with 32% ADF (52% TDN @ 90% DM), the alfalfa with 28% ADF (55% TDN @ 90% DM) is worth from \$7 to \$19 more per ton depending on the level of milk production of the cows consuming it. Conversely, the alfalfa with 37% ADF (49% TDN @ 90% DM), is worth from \$9 to \$140 per ton less depending on the milk yields of the cows consuming it. The difference in relative values between the 28% ADF and 37% ADF hay lots is from \$16 to \$159 per ton depending on milk yields of cows being fed the alfalfa.

Table 4: Relative economic values (\$/ton) of alfalfa hay lots varying from 28% to 37% ADF (55% to 49% TDN at 90% DM).

Milk Production Group	Low	Medium	High	Super
28% ADF (55% TDN) 127	127	131	139	
32% ADF (52% TDN) 120	120	120	120	
37% ADF (49% TDN) 111	108	81	-20	
Difference (28% ADF vs. 37% ADF)	\$16	\$19	\$50	\$159

Using Table 6, Relative Alfalfa Hay Values at Various ADF Percentages, in the bulletin “Testing Alfalfa for Its Feeding Value” (Bath and Marble, 1989), the difference in relative economic value between alfalfa hays with 28% and 37% ADF is calculated as \$15 per ton based only on digestibility. This is very close to the \$16 difference determined by PCDAIRY for low-yielding cows, but grossly underestimates the difference in relative values for high-yielding cows.

Managers of large dairy herds can use programs such as PCDAIRY to determine relative dollar values of various lots of alfalfa hay offered for sale. When the price spread between low- and high-fiber alfalfa is large, it may be cost-effective to purchase and feed the lower-priced, high-fiber hay to low-producing cows, dry cows, and growing heifers. However, it appears that there would have to be a tremendous price spread for it ever to be cost-effective to feed high-fiber alfalfa as the main forage source to high-producing cows within a herd.

Corn Silage

The nutritional value of corn silage is less affected by stage of maturity than alfalfa. As the corn plant matures, digestibility of the stalk decreases due to increased lignification, but this is offset by the concurrent development of the grain kernels which are highly digestible. Fiber content of the corn plant varies little between the milk stage and dent stage of kernel development. Thus, fiber content of corn silage is not a good predictor of its maturity.

Forage dry matter yield per acre and palatability of the silage are the most important economic factors for corn silage. Maximum dry matter yield occurs at physiological maturity of the corn plant when all kernels are fully dented. However, digestibility and palatability of the total plant decreases after this point, so a good compromise is to harvest corn for silage when the milk line is 2/3 of the way down the kernel. The corn plant contains about 65% moisture at this stage, which is ideal for fermentation of the forage in horizontal silos. Harvesting at a less mature stage is undesirable because forage dry matter yield per acre is reduced, the grain portion of the silage is reduced, and additional expenses are incurred to haul water contained in the forage. If the forage contains more than 72% moisture, seepage from bunker and stack silos is likely, resulting in further economic losses from nutrients lost in the runoff.

Harvesting corn after physiological maturity also results in economic losses. Yields are decreased due to excessive field losses from stalk breakage, leaf loss, and dropped ears. Further losses occur in horizontal silos due to difficulty in packing forage that is too dry (less than 62% moisture), resulting in losses from heating and oxidation of the silage.

Maximum economic benefits are obtained from feeding corn silage that is harvested when the milk line is 2/3 of the way down the kernel, the silo is filled rapidly, the forage is well-packed, and air and rain water are excluded from the silage mass. In the case of horizontal silos, the silage should be covered with plastic held down by automobile tires, or by other materials that will prevent air and water from contacting the silage. If the silage mass in horizontal silos is not covered and packed well, as much as 50% of the total silage may be lost from heating, oxidation, and run-off due to exposure to the elements.

Winter Cereals

Digestibility and feeding value of cereal forages are greatest at an immature stage (boot-stage), but as is the case with corn silage, the fiber content of cereals is not a good predictor of maturity. As the fiber content of the stem increases with maturity and becomes less digestible, the cereal grain kernels are developing at the same time. The grain, being very low in fiber, dilutes the increasing fiber content of the stem, resulting in very little change in total plant fiber content as the cereal plant matures. In fact, there is a slight decrease in fiber content as a cereal, such as oats, goes from the flower stage to the dough stage of kernel development (DePeters et al., 1989), resulting in a curvilinear relationship between fiber and maturity as the cereal plant goes from the early vegetative stage to full maturity. Therefore, the laboratory test for fiber used to estimate maturity and feeding value of alfalfa is inap-

propriate for cereal forages. Unfortunately, at the present time there is no laboratory test that can accurately estimate the feeding value of cereal forages.

Although there is no reliable laboratory test to predict the feeding value of cereal forages, feeding trials have demonstrated the superiority of oats harvested at the boot-stage compared with more mature stages. Data from research with oat forage conducted at U.C. Davis in the 1950's (Meyer et al., 1957) are shown in Table 5.

Table 5: Yield, composition and nutritional value of oat forage harvested at various stages of maturity.

	59% Jointing	16% Flag Leaf	21% Boot	1% Flower	18% Flower	44% Milk	42% Dough
DM (lb/Ac) 1800		4300 5400	5800	8000	9400	9200	
Lignin (%) 3.8		4.3 4.9	5.8	6.4	9.0	8.4	
Crude fiber (%)	16	19	21	24	27	29	27
Crude protein (%)	24	19	18	16	14	12	2
T.D.N. (%) 68		65 65	64	60	50	53	

Harvesting at the boot-stage results in less forage tonnage per acre (Table 5), but the available forage is more nutritious to the animal consuming it. How much is that higher nutritive value worth? The same procedure, as previously described in the alfalfa section of this paper, was used to answer that question.

A comparison was made of two oat silages, one harvested at the boot stage and the other at the soft dough stage. Nutrient values for the two silage samples were taken from the bulletin, "Nutrient Requirements of Dairy Cattle" (National Research Council, 1989). For comparison purposes, the soft dough stage silage was specified to be worth \$25 per ton at 30% dry matter. Alfalfa hay at \$100 per ton was restricted to seven pounds per cow daily to ensure that oat silage would comprise most of the forage in the ration. Milk price was specified to be \$12 per hundredweight, and other feedstuffs available for the rations and their prices were the same as those used in the alfalfa example previously discussed.

Rations were formulated for four milk yields with each of the oat silages. A summary of milk yields, feed costs, and income over feed costs (IOFC) using the dough stage silage is shown in Table 6. Daily feed costs increased from \$2.40 per cow for 45 lb of milk to \$4.00 per cow for 94 lb of milk, which was the highest milk yield possible with this quality of silage as the major forage source. Daily IOFC increased even faster from \$3.00 per cow for 45 lb of milk to \$7.29 per cow for 94 lb of milk, illustrating the increased profitability of high-producing cows.

Table 6: Milk yields, feed costs, and income over feed costs of cows fed a ration based on oat silage harvested at soft dough stage.

		Milk Production Group			
		Low	Medium	High	Super
Milk (lb/day)		45	65	83	94
Oat silage (\$/ton)		25	25	25	25
Feed costs (\$/day)	2	.40	3.13	3.67	4.00
IOFC* (\$/day)		3.00	4.67	6.29	7.29

*IOFC = Income over feed costs.

In a second set of computer formulations, the price of boot stage oat silage at 30% dry matter was allowed to vary so that IOFC would be the same as it was for the previous rations using dough stage silage at \$25 per ton. All other feed prices remained the same as the previous example. The results are shown in Table 7. The relative value of boot stage oat silage varied from \$39.92 per ton for the low-yielding cows to \$78.26 per ton for the high producers. Also, it should be noted in Table 7 that a ration could be formulated for a cow producing 105 lb of milk daily with boot stage oat silage compared with a maximum of only 94 lb daily with dough stage silage. Higher maximum milk yield is possible because a cow can eat more total feed when her ration is based on the higher protein, more digestible, and more palatable boot stage silage. As was the case in the alfalfa example, this again illustrates the well-known fact that high-producing cows must be fed high-quality forages as well as liberal amounts of grain concentrates in order to maintain high milk yields.

Table 7: Milk yields, relative economic values of oat silage, feed costs, and income over feed costs of cows fed a ration based on oat silage harvested at the boot stage.

	Milk Production Group			
	Low	Medium	High	Super
Milk (lb/day)	46	65	85	105
Oat silage (\$/ton)	39.92	42.37	45.19	78.26
Feed costs (\$/day)	2.52	3.13	3.91	5.31
OFC* (\$/day)	3.00	4.67	6.29	7.29

*IOFC = Income over feed costs.

The relative values of the two silages at the four levels of milk production are summarized in Table 8. Assuming a price of \$25 per ton for dough stage oat silage, boot stage silage is worth from \$14.92 to \$53.26 more per ton depending on the level of milk production of the cows consuming it. Therefore, under the conditions used in this example, relative value of boot vs. dough stage oat silage varies from 160 to 313%.

Table 8: Relative economic values (\$/ton @ 30% dry matter) of oat silage harvested at the boot and soft dough stages of maturity.

	Milk Production Group			
	Low	Medium	High	Super
Oat silage, boot stage (\$/ton)	39.92	42.37	45.19	78.26
Oat silage, dough stage (\$/ton)	25.00	25.00	25.00	25.00
Difference (\$/ton)	14.92	17.37	20.19	53.26
Rel. value, boot vs. dough (%)	160	169	181	313

There is no question that boot stage silage is more nutritious than dough stage silage. However, there are several other factors that should be considered, such as:

1). Harvesting at the boot stage results in less forage dry matter per acre than at the dough stage. However, if the land is being double-cropped with corn for silage, increased corn silage yields due to an earlier planting date for the corn may more than make up for reduced cereal silage yields.

2). Cereals harvested at the boot stage should be field-wilted to about 30% dry matter before ensiling. Direct-chopping should be avoided because boot stage forage is too high in moisture for good fermentation. Field-wilting adds another step to the harvest process, but the lower moisture content of the wilted forage results in less hauling costs from the field to the silo.

3). Cereals harvested at the boot stage require less water in areas where spring irrigations are necessary because fewer irrigations are needed. That fact may become even more important in areas where irrigation water is limited and demand for water for non-agricultural purposes continues to increase, as is the case in many western states.

In summary, the answer is a definite “yes” to the original question: “Does stage of maturity at harvest affect the feeding value of cereal silages?” How much the improved nutritional value is worth depends on the level of milk production of the cows consuming the silage. With the inputs used in this example, boot stage oat silage was worth from 160% to 313% of dough stage silage. If the silage is being fed to low-producing cows, dry cows, or growing heifers, the increased nutritional value of boot stage may be more than negated by decreased forage yields per acre. However, if the silage is used as a major part of the ration for high-yielding cows, the economics definitely favor cereal silage harvested at the boot stage.

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Water Nutrition And Quality For Dairy Cattle

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Introduction

Doubtless, water is the most important dietary essential nutrient. Loss of about 1/5 of body water is fatal. Lactating dairy cows need larger proportions of water relative to body weight (BW) than most livestock species because water comprises 87% of milk. Factors influencing daily water intake and requirements include physiological state, milk yield (MY), dry matter intake (DMI), body size, rate and extent of activity, diet composition including types of feedstuffs (e.g., concentrate, hay, silage or fresh forage), ambient temperature, and other environmental factors (e.g., humidity and wind velocity). Other factors affect how much of a particular water supply is consumed; included are salinity, and sulfate and chloride contents, dietary Na content, temperature of water, frequency and periodicity of watering, social or behavioral interactions of animals and other quality factors such as pH and toxic substances. This paper addresses practical considerations of water nutrition, needs during heat stress, effects of chilling drinking water, and factors affecting water quality.

Functions and Metabolism.

Water is ubiquitous within the body and is a great solvent. It is chemically neutral; thus, ionization of most substances occurs more freely in water than other media. Water serves as a medium for dispersion or suspension of colloids and ions within the body, and is necessary for maintaining osmotic balance. It functions as a medium for processes of digestion (hydrolysis), absorption, metabolism, milk and sweat secretion, and elimination of urine and feces. It provides a medium for transport of nutrients, metabolites, hormones, and gases and is a lubricant and support for various organ systems and the fetus. A special role is in heat exchange and maintenance of heat balance because of its high thermal conductivity, allowing rapid transfer of heat. High latent heat of vaporization allows cows to transfer significant heat from their bodies to the environment with only a small loss of water volume; high heat capacity provides a thermal buffer by conserving body heat in cold climates and conserving body water in warm environments.

Water balance is affected by total intake of water and losses arising from urine, feces, milk, saliva, sweating, and vaporization from respiratory tissues. Amounts lost via various routes are affected by amount of milk produced, ambient temperature, humidity, physical activity of the animal, respiratory rate, water consumption and dietary factors (e.g., Na or N contents).

The equation was:

$$\begin{aligned} & \text{water intake (lb/day)} \\ &= 0.90 \times (\text{MY, lb/d}) + 1.58 \times (\text{DMI, lb/day}) \\ &+ 0.11 \times (\text{Na intake, g/day}) \\ &+ 2.64 \times (\text{oF/1.8} - 17.778, \text{ average} \\ & \text{minimum temperature}) + 35.25 \end{aligned}$$

Water Intake and Requirements. Water requirements of dairy cattle are met from three sources: (1) that ingested as drinking water, (2) that contained on or in feed con-

sumed, and (3) that resulting from metabolic oxidation of body tissues. Murphy et al. (1983) developed a prediction equation to estimate intake of drinking water. Data were from the first 16 wks of lactation of 19 multiparous Holstein cows (average BW 1276 lb) averaging 73 lb MY/day. Diet was approximately 40% corn silage and 60% concentrate, dry basis. Sodium intake varied because sodium bicarbonate was fed to part of the cows. Factors included in the prediction equation were DMI (lb/day), MY (lb/day), Na intake (g/day), and weekly average minimum environmental temperature (*F). Ranges and averages for independent factors from the data set used to develop the equation were: 7.7 to 112.3, 72.9 lb MY/day; 11.4 to 59.9, 41.8 lb DMI/day; 12 to 153, 74 g Na intake/day; and, 9.0 to 68.0, 46.5 °F, average minimum temperature.

Table 1 depicts relative influence of these factors on drinking water intake. Values of factors used generally are within ranges of data utilized to develop the prediction equation. Actual average minimum temperature (*F) was characterized within cool (Dec, Feb, and Apr) and warm (Jun, Aug, and Oct) season categories from weather data at Gainesville, FL (Whitty et al. 1991). Milk yield and DMI were estimated, with typical expected declines in DMI in warm season when MY was 60 lb/cow/day or more. Sodium intake (g/day) was calculated based on specified DMI and dietary Na concentrations of 0.18% (NRC, 1989) or 0.50% which would be typical of diets with supplemental Na-containing buffer. Water contained on or in feeds consumed was not considered in prediction; water con-

Table 1: Predicted daily water intake of dairy cattle as influenced by MY, DMI, Na intake, and average minimum temperature (season and month). 1,2

Cool Season						
		Dec	Feb	Apr		
min. mo temp		51.2	43.5	51.0		
max. mo temp		75.6	68.6	76.7		
avg. mo temp		63.4	56.1	63.8		
		MY (lb)	DMI3 (lb)	Na4 (g)	water intake (gals/day)	
0	25	20	12.6	11.2	12.6	
20	38	31	17.4	16.0	17.3	
		86	18.1	16.7	18.0	
40	40	33	19.9	18.6	19.9	
		91	20.7	19.3	20.6	
60	45	37	23.1	21.7	23.0	
		102	23.9	22.6	23.9	
80	50	41	26.2	24.9	26.2	
		114	27.2	25.8	27.2	
100	55	45	29.4	28.0	29.3	
		125	30.4	29.1	30.4	
120	60	49	32.5	31.4	32.5	
		136	33.7	32.3	33.6	
Warm Season						
		June	Aug	Oct		
min. mo temp		62.8	71.0	69.6		
max. mo temp		87.9	91.6	89.1		
avg. mo temp		75.2	81.3	79.3		
		MY (lb)	DMI3 (lb)	Na4 (g)	water intake (gals/day)	
0	25	20	4.6	16.1	15.8	
20	38	31	19.4	20.8	20.6	
		86	20.1	21.6	21.4	
40	40	33	22.0	23.4	23.1	
		91	22.7	24.2	24.0	
60	44	36	24.9	26.3	26.1	
		100	25.8	27.2	27.0	
80	46	38	27.5	28.9	28.7	
		104	28.3	29.8	29.6	
100	48	39	30.0	31.5	31.2	
		109	30.9	32.4	32.2	
120	50	41	32.6	34.0	33.8	
		114	33.5	35.0	34.8	

1: Drinking water intake predicted from equation of Murphy et al. (1983); equation uses average minimum temperature (*F).

2: Average minimum, maximum and average monthly temperatures are 70-year averages for specified months at Gainesville, FL (Whitty et al., 1991).

3: Estimated DMI.

4: First row within each MY by DMI by average minimum temperature category is with dietary Na % = 0.18 (NRC, 1989); second row is with Na % = 0.50, typical of feeding a Na-containing buffer.

tent of experimental diets to develop equation was about 38% (Murphy et al. 1983). Water intake in gallons per day can be calculated by multiplying lb/day by 0.1198.

The prediction equation indicates that intake of drinking water changes 0.90 lb for each 1.0 lb change in MY, 1.58 lb for each 1.0 lb change in DMI, 0.11 lb for each 1 g change in Na intake, and 1.47 lb for each 1°F change. Thus, DMI has the most relative influence on water intake. However, absolute magnitude of change of various factors has direct bearing on how much water intake will be affected. For instance, because possible range in MY is greater than DMI it could affect water intake more (Table 1). Based on the prediction equation, cattle consume 0.19 gallon of water for each lb increase of DMI and 0.11 gallon for each lb increase in MY when the other three independent variables of the equation are held constant.

Sodium has a relatively small influence (3-4% increase) on water intake when Na content is increased from 0.18 to 0.50% of diet DM (Table 1). Using 70-yr average minimum temperatures of Feb and Aug, water intake increased about 25% during the warmer month when DMI, MY and Na intake were the same. Winchester and Morris (1956) found a relatively constant ratio of 3 lb of water consumed/lb of DMI within temperature range of 0 to 41°F. However, water intake per unit of DMI accelerated rapidly as ambient temperature rose above 41°F, reaching over 7 lb of water/lb DMI at 90°F.

Other Factors Affecting Water Intake.

Diet Moisture Content. Dairy cattle consuming typical air-dry (about 90% DM) diets consume less than 1 gallon of water from feed daily, depending on feed intake. This quantity is small compared with drinking water (Table 1). By comparison, when cattle consume pastures, silages, and liquid feeds, a substantial portion of water needs is provided. A typical diet for lactating cows containing 50% water would result in intake of 50 lb (6 gallon) of water if feed intake was 100 lb as-fed; this would be equal to about 17-23% of predicted drinking water intake depending on MY and average minimum temperature, based on equation of Murphy et al. (1983). Belgium workers found a negative relationship between total water intake and DM content of ration when evaluated at constant DMI (Paquay et al. 1970). In an equation developed from several pasture experiments, total water intake was affected negatively by DM content of the ration, and positively by DMI and mean temperature (Stockdale and King, 1983). Davis et al. (1983) investigating feeding value of wet brewers grains, showed that total water consumed (drinking water intake plus that derived from the ration) decreased about 26% as total ration moisture content increased from 30.7 to 53.6%. Drinking water intake, per se, declined 37% over this range of ration moisture contents. However, this effect may have been more a function of actual DMI, because as total ration moisture content increased from 30.7 to 53.6%, actual DMI declined 24%. Substantial influence of DMI on drinking water intake was evident.

Metabolic Water. When organic compounds are oxidized by animals, hydrogen molecules go towards formation of metabolic water. During metabolic oxidation, water yields (ml/g tissue) are 1.07 from fat, 0.40 from protein, and 0.50 from carbohydrate. This can account for as much as 15% of total water intake (Chew, 1965), which is substantially more than from consumption of an air-dry ration. Although oxidation (e.g., protein catabolism) contributes metabolic water, there also are increased demands for water for respiration, heat dissipation and urine excretion associated with oxidative processes. Thus, generation of metabolic water is not adequate to cover other demands associated with oxidation. Additional sources of water (e.g., drinking or feed-borne water) are required for metabolic oxidation.

Drinking Behavior, Waterer Characteristics and Stray Voltage. Pattern of water consumption is associated with feeding pattern (Nocek and Braund, 1985). When four first lactation cows were fed one, two, four or eight times daily, peak hourly water intake was associated with peak times of DMI. Cows would alternate the intake of feed and water.

Given the opportunity, peaks of drinking can be associated with milking. Typically, greater consumption is observed immediately after milking. Therefore, it seems judicious to provide abundant water to cows immediately after milking such as in the return lanes. Some dairies provide water cups or troughs for cows in the milking parlor. However, field observations suggest intake at this location is not appreciable (D. K. Beede, personal observation). This may be because water was quite cool (about 55°F) and thus not as acceptable to cows (Wilks et al., 1990). A field observation in southeastern Georgia suggested that cows preferred warmer water (about 80°F) coming from a heat-exchange unit in the milking parlor compared with well water (about 65°F) in summertime. Water temperatures between 60 and 80°F appear most acceptable to dairy cattle.

The type of water receptacle may affect drinking behavior. Compared on a herd basis in Europe, cows drank less frequently from water troughs than from water cups (bowls) (Castle and Thomas, 1975). Total daily drinking time ranged from 2.0 to 7.8 min, with longest time found for a herd which had only water cups. Drinking rate ranged from 1.2 to 6.5 gallon per min. The lowest rate was with water cups. Total daily intake was highest with drinking cups, but this likely was biased by herd and diet differences.

Filling rate of water cups can affect water intake and is largely a function of pipe size and water pressure. Reid (1992) noted that during renovation of a tie-stall barn, 2-inch PVC water pipe replaced 1-inch galvanized pipe. Larger diameter pipe facilitated more rapid filling of water cups and MY increased 3 lb during summer in Wisconsin when cows were housed 14 hr/day. Actual flow rates into water cups before and after the change were not given. In Sweden, water intake behavior from cups with flow rates of .5, 1.8 and 3.2 gallon per min was examined (Anderrson et al., 1984). Time spent drinking decreased from 37 to 11 and 7 min/day as flow rate increased. Frequency of drinking episodes was 40, 28 and 30 times/day. As flow rate increased, total water intake increased from 20.4 to 22.0 and 23.3 gallons per day. However, MY and composition and DMI were not affected by flow rate into water cups. In this experiment, each cow of a pair sharing the same water cup was classified as dominant or submissive based on videotaped behavior of frequent confrontations in drinking episodes. Submissive cows consumed 7% less water and ate 9% less hay than dominant cows. Milk fat % and FCM yield also were lower for submissive cows.

Use of water cups in most large herds is relatively infrequent for obvious reasons. However, watering troughs with adequate accessibility and flow rates are important, because cows tend to drink in groups associated with other events (e.g., feeding or after milking). Therefore, adequate linear dimension and filling rate of the water receptacle are required to accommodate the group's needs. Otherwise, more submissive cows may not have adequate opportunities to consume water and may not return to the water trough at a later time.

Potential for stray voltage at or around water tanks or other receptacles is worth considering. In a recent study, lactating Holstein cows adapted to being subjected to 3 volts AC or less between the water bowl and the rear feet (Gorewit et al., 1989). About 91% of cows subjected to 4 to 6 volts adapted within 2 days so that there was no change in water intake. However, some cows refused to drink within the first 36 hrs of subjection to 4 volts or more and treatment was ended. There also was a direct relationship between amount of voltage applied

and time required for cows to adapt and consume their first gallon of water. When 6 volts were applied, over 11 hrs were required before the first gallon of water was consumed. Probably stray voltage is not a prevalent problem. However, it should be evaluated if lactational performance and water intake are less than expectations. Use of water heaters in cold climates may contribute to stray voltage problems.

On a practical basis, it seems obvious that a fresh, clean, abundant, easily accessible supply of drinking water must be available at all times to dairy cattle. However, based on numerous farm visits, this is not always the case (D. K. Beede, personal observation). If a herd or group is not performing to expectations, one of the first factors that should be evaluated and monitored is the drinking water.

Water Nutrition of Young Calves.

During early life (0 to 3 wks), suckling calves consume 0.20 to 0.40 gallon of water daily via milk or milk replacer. Young calves fed liquid diets consume more water per unit DMI than do older cattle fed dry diets (ARC, 1980). Water intake accelerates as calves begin to consume larger amounts of dry feeds. Providing free access to drinking water increased DMI and BW gain (37% increase) of young calves fed a liquid diet (89% water) compared with calves fed only liquid diet (Kertz et al., 1984). There was no indication that offering free-choice drinking water produced scours. Some times producers do not offer free-choice drinking water to young calves. This practice appears detrimental and may be perilous, e.g. in heat-stressing environments when the physiologic demand for water to aid in thermoregulation may be higher. Additionally, the notion that restriction of free-choice drinking water enhances intake of liquid milk replacers seems equally dangerous when demands from stress are great. Performance and health of young calves is superior when fresh drinking water is offered free-choice at all times. Proper and timely sanitation of water receptacles obviously is extremely important.

Drinking Water During Hot Weather and Effects of Chilled Water.

Water Needs During Heat Stress. Many large dairy herds are located in warm climates. Water unequivocally is the most important nutrient for lactating dairy cows in heat-stressing environments. Water is the primary medium for dissipation of excess body heat through lungs and skin in addition to that required in milk. USDA research showed total water loss from the body increased by 58% in nonlactating cows maintained at 86°F compared with 68°F. Much of the increase was due to increased (176%) secretion of water through skin as sweat (McDowell and Weldy, 1967). Concomitantly, loss of water in feces decreased 25%, but increased 54% and 26% via respiratory and urinary routes at 86°F compared with 68°F. For lactating cows in climate chambers (64 vs 86°F), drinking water consumption increased 29% at the warmer temperature; fecal water loss dropped 33%, but loss of water via urine, skin surface and respiratory evaporation increased 15, 59 and 50% (McDowell, 1972). Marked increases in water intake were observed starting at 81 to 86°F with lactating cows (Winchester and Morris, 1956; NRC, 1981). Cows also consumed less water in high humidity than lower humidity environments, probably because of reduced DMI and dampened ability to employ evaporative heat loss mechanisms.

Surprisingly little is known about actual requirements for water during heat stress. Numerous factors, such as rate of feed intake and physical form of the diet, physiological state, breed of animal, and quality, accessibility and temperature of water, likely affect intake dur-

ing heat stress (NRC, 1981). Studies in climate chambers suggested that water needs under heat stress are 1.2- to 2-fold higher than required of cows producing in the thermal comfort zone. Using the prediction equation of Murphy et al. (1983), intake of drinking water increased 1.25-fold in Aug compared with Feb for the same MY by DMI by Na intake category (Table 1). Under natural conditions, particularly with potential for plentiful natural ventilation and sweating, water expenditure may be even greater.

Inadequate provision of water decreases milk production faster and more dramatically than any other nutritional factor. If milk production drops dramatically, particularly during summer, water supply should be evaluated. All too often, dirty water tanks or improper placement of waterers may be the culprit. A good guideline is, "Based on appearance of cleanliness, would you be willing to drink from the tank? If the answer is no, it is not clean enough for cows." A second frequent problem is that waterers or tanks are placed too far away from shade where cows spend their time during the hottest part of the day. If cows must choose between shade and walking to an unshaded watering station, they stay in the shade. During this time cows use much of their available body water to dissipate heat through evaporation, reducing that available for synthesis of milk. Waterers should be placed in shade in close proximity to cows; this also keeps water from getting hot from solar radiation which can reduce water intake.

Drinking Water Temperature.

Researchers at Texas A&M University compared cooling effects of chilled drinking water (50, 61, 72 and 82°F; Stermer et al., 1986). All water was withheld for 6 hrs before offering to cows. Inner ear temperature was reduced more with 50°F water than 82°F water. However, 50°F water was only 32% effective in reducing body temperature and authors were doubtful if the effect was maintained long enough (about 2.2 hr) to keep body temperature from rising above the upper critical temperature. There were no differences in MY of cows offered drinking water at various temperatures. This, coupled with estimated cost to chill water from 82 to 72°F (\$.049/cow/day) or to 50°F (\$.125/cow/day) led to the conclusion that there probably was no advantage to chilling drinking water for lactating cows. In another study, cows offered chilled (50°F) water had greater DMI (15% increase) and produced more 3.5% FCM (11% increase) than those drinking 82°F water (Milam et al., 1986).

Cows were offered 51° or 81°F water on a 24 hr basis in a switchback design (Wilks et al., 1990). Cows offered cooler water consumed more feed (3%), drank more water (7.7%) and had reduced respiration rates and rectal temperatures. Milk yield was increased 4.8% for cows consuming chilled water. An alternative to chilling water may be to insulate water tanks to maintain a lower water temperature if it comes from the well (or other source) relatively cool. Measurements in Florida indicated a temperature range of well water of 73-79°F immediately after pumping, considerably cooler than the high temperature treatments used in most of the Texas A and M University experiments. The practical approach seems to be to prevent well water from warming after it is pumped and stored above ground.

Cows exhibited preference when offered 50° or 86°F drinking water cafeteria-style (Wilks et al., 1990). Respiration rates and rectal temperatures were reduced with cooler water. However, cows preferred to drink warmer water given the choice, with over 97% of total water consumed being warmer water. Over 70% of cows drank only warm water. It was concluded that if chilled drinking water was offered as way to cool cows, it must be the only source of drinking water available. Otherwise, cows may wait to drink until a time when warmer water is available.

Well water (77°F) or chilled (59°F) drinking water was offered on a large Florida dairy (Bray et al., 1990). Cows were kept in open lots with cooling ponds and two shade structures per lot. Cows did not have access to feed and water under shades. Four watering stations (unshaded) were in each lot. Over 1,100 cow-period observations were collected in a reversal design from June through September. Mean daily minimum, maximum, and average ambient temperatures and mean daily minimum relative humidity were 68.4, 91.0 and 79.7°F, and 58%. Under these conditions there was no difference in MY (61.4 vs 61.8 lb/day) for cows offered well or chilled water.

A similar experiment was performed the following year on another commercial dairy where cows were kept in feeding barns with fans and sprinklers, and had access to feed and water continuously (Bray et al., 1991). Mean daily minimum, maximum, and average ambient temperatures and mean daily minimum relative humidity were 66.3, 91.3 and 78.8°F, and 50.5%. There were about 175 cows per treatment and drinking water temperatures were well water (75-80°F) and chilled water (52-57°F) in a 2-mo. reversal experiment. Water consumption from total group measurements averaged 21.7 and 23.2 gallons per cow per day for well water and chilled water. There was no difference in intravaginal temperatures as detected by thermal couples with radio transmitters. Average MY was 63.1 and 64.2 lb/d, for well and chilled water treatments, but were not significantly different.

In a survey of over 200 drinking water tanks on 31 dairies in central Florida in summer (Giesy, 1990 cited by Bray et al., 1991), overall average water temperature was 86°F, and ranged from 77-97°F. Shading tanks lowered temperatures somewhat with average water temperatures of 87, 85, 81 and 81 when tanks were unshaded, shaded during the morning, shaded during the afternoon or continuously shaded. Average temperature of fresh water at the tank inlet was 82°F, and was affected by the distance water traveled before entering the tank. Fresh water inlet temperature to the tank was higher (82°F) if pipe servicing the tank was above ground for 200 ft or more, compared with less than 100 ft (79°F). Volume capacity of tank relative to number of cows it serviced affected tank water temperature. When tank capacity was less than 1 gallon per cow, water temperature was 82°F. At tank capacities of 1-3, 4-9, 10-19, 20-39 and over 40 gallons per cow, temperatures of water in tanks were 85, 86, 87, 88 and 91°F. This information emphasizes the benefit of relatively small volume, rapidly filling tanks for cows in warm climates. Access to sufficient linear space of an abundant water supply probably is more important than tank capacity.

Main consideration for water nutrition during hot weather is to provide an easily accessible source of clean drinking water in close proximity to cows. This should be in the shade so that water in the tank or waterer is not heated excessively above that temperature which it comes from the well. Additionally, chilling drinking water probably is not warranted except where water comes from the well at temperatures above 86°F or where water cannot be kept reasonably cool by shade, specifically designed drinking water receptacles, and (or) insulation.

Water Quality and Factors Affecting Performance

The most extensive review of water quality factors was by the NRC (1974) subcommittee on nutrients and toxic substances in water for livestock and poultry. Water quality is an extremely important issue both in terms of quality of drinking water provided to livestock and in terms of quality of water leaving production units as a potentially renewable resource. The latter is not considered in this paper.

Five criteria can be considered when evaluating drinking water quality: organoleptic, physio-chemical, substances present in excess, toxic compounds, and microorganisms (primarily bacteria). Organoleptic factors (e.g., odor and taste) may be readily detectable by the animal, but are of little direct consequence to health or productivity unless water consumption is affected dramatically. Physio-chemical properties, i.e. pH, total dissolved solids, hardness, and total dissolved oxygen are used to classify broadly water sources and generally do not present direct health risks but may indicate underlying problems. Excess of some chemicals normally found in water (i.e. nitrates, Fe, Na, sulfates, and FI) may be health risks or depress water consumption. Toxic substances may be common in water but generally are below dangerous concentrations; examples are As, cyanide, Pb, Hg, hydrocarbons, organochlorides, and organophosphates. Maximum bacterial concentrations of potable water for humans are regulated; however, less control is exercised for drinking water for livestock, but potential hazards might exist in some circumstances.

Table 2: Guide to use of saline waters for dairy cattle; total dissolved solids equals TDS.

TDS (mg/l or PPM)	comment
less than 1000 (fresh water)	Presents no serious burden to livestock.
1000-2999 (slightly saline)	Should not effect health or performance, but may cause temporary mild diarrhea.
3000-4999 (mod. saline)	Generally satisfactory, but may cause diarrhea especially upon initial consumption.
5000-6999 (saline)	Can be used with reasonable safety for adult ruminants. Should be avoided for pregnant animals and baby calves.
7000-10000 (very saline)	Should be avoided if possible. Pregnant, lactating, stressed or young animals can be affected negatively.
over 10000 (nearing brine)	Unsafe. Should not be used under any conditions.

Examples are As, cyanide, Pb, Hg, hydrocarbons, organochlorides, and organophosphates. Maximum bacterial concentrations of potable water for humans are regulated; however, less control is exercised for drinking water for livestock, but potential hazards might exist in some circumstances.

Salinity and Total Dissolved Solids. Salinity refers to the amount of dissolved salts present in water. First consideration generally is sodium chloride, but other dissolved inorganic constituents such as carbonates, sulfates, nitrates, K, Ca, and Mg are in the same category. These constituents

may affect osmotic balance of animals and generally are measured as total dissolved solids (TDS). Table 2 adapted from NRC (1974) provides a guide to use of saline waters.

Jaster et al. (1978) studied effects of water salinity on lactation. Tap water (196 ppm) was compared with drinking water containing 2,500 ppm dissolved sodium chloride offered to 12 lactating cows averaging 82 lb MY/day at the beginning of the experiment. Water intake was 7% greater, but feed intake and MY tended to be less for cows offered high saline water. Minerals in blood and milk, and diet digestibilities were similar between treatments, but urine and fecal Na, and urine Cl were higher for cows offered drinking water containing high amounts of salt. Other studies suggested no effect of drinking water containing 15,000 ppm (Heller, 1933) and 10,000 ppm (Frens, 1946) sodium chloride, or 5,895 ppm sodium sulfate. However, Frens (1946) reported reduction in MY with 15,000 ppm sodium chloride. Also in Arizona, Holstein heifers showed an increasing preference for drinking water as salinity approached 2,000 ppm, but water consumption dropped dramatically when salinity was greater than 2,500 ppm (Wegner and Schuh, 1974). In growing beef heifers, consumption of drinking water with 12,500 to 20,000 ppm sodium chloride caused symptoms of salt toxicity (Weeth and Haverland, 1961).

In a recent study in Saudi Arabia during warm weather, Challis et al. (1987) found that desalination of drinking water originally containing about 4,400 ppm TDS, of which 2,400 ppm were sulfates, improved MY by 28% (77 vs 60 lb/day), increased water intake 20% and increased grain intake 32% compared with high saline water. Desalinated water contained 441 ppm TDS. When high saline water was reintroduced, MY dropped 13.2 lb/day during the first week. This study suggests that a combination of high TDS in drinking water and hot weather can be particularly deleterious for lactating cows.

Maximum tolerable concentrations of sulfates in drinking water were investigated in Nevada. Growing cattle were affected adversely by 3,493 ppm sulfate in their drinking water. Feed and water intakes were reduced and methemoglobin concentration was increased (Weeth and Hunter, 1971). In a subsequent study, 1,462 ppm or 2,814 ppm sulfate-water made by adding sodium sulfate to tap water reduced hay intake, but not water consumption of Hereford heifers compared with controls (110 ppm sulfate in drinking water) (Weeth and Capps, 1972). Rate of BW gain was reduced by water containing the highest sulfate concentrations. Drinking water with 2,814 ppm sulfate increased methemoglobin concentrations and significantly altered renal function. These researchers concluded that the tolerable concentration of sulfate in drinking water for growing beef cattle in summer in Nevada was near 1,450 ppm.

In a follow-up study designed to define more accurately maximum tolerable concentrations of inorganic sulfate in drinking water, Digesti and Weeth (1976) offered 110, 1,250 or 2,500 ppm sulfate in drinking water, with higher concentrations added as sodium sulfate. Feed consumption, water intake and growth rate of beef heifers were not affected by higher sulfate drinking water during the 90-day experiment. No overt toxicity was detected. However, heifers given water with 1,250 or 2,500 ppm sulfate tended to accumulate more methemoglobin and sulfhemoglobin without a decrease in concentration of total blood hemoglobin. Sulfate loading did not cause diuresis, although renal filtration of sulfate was increased by the highest sulfate treatment. It appeared that 2,500 ppm sulfate in drinking water was tolerated by these heifers without adverse effects, and it was suggested to represent a safe tolerance concentration. In a companion study, sulfate (3,317 ppm estimated rejection threshold) in drinking water was found to be more unpalatable than Cl (5,524 ppm estimated rejection threshold). Recent evidence suggests that high dietary intakes of the anions, sulfate and Cl, can perturb acid-base balance of cattle (Wang and Beede, 1992). Abnormally high intakes of these anions in drinking water likely are responsible for detrimental effects on animal health and productivity. Their negative influence likely is more marked than that of high Na intake.

If anti-quality factors (e.g., high TDS, Cl or sulfates) are suspected of affecting animal performance, concentrations in drinking water should be determined. Water intake can be estimated from equation of Murphy et al. (1983) or by using water meters. It may be feasible to adjust amounts of minerals supplemented in the diet so that total intake (from water plus feed) is more nearly those recommended. Alternatively, processes to reduce concentrations of minerals in water (e.g., dilution, ion exchange or distillation), may be possible, though possibly costly.

Nitrates (nitrites). Nitrate poisoning (nitrite poisoning) results from conversion of nitrate to nitrite by ruminal microorganisms and subsequent conversion of hemoglobin to methemoglobin by nitrite in blood. This reduces dramatically the oxygen carrying capacity of blood and can result in asphyxiation in severe cases.

One 35-mo study in Wisconsin compared reproductive efficiency and lactational performance of a 54-cow herd in which drinking water contained 19 ppm or 374 ppm nitrate (added

as potassium nitrate; Kahler et al., 1975). During the first 20 mo of study there were no effects on reproductive function as assessed by incidences of abortions, retained fetal membranes, cystic ovaries, observed heats, services per conception, and first-service conception rates. During the latter 15 mo of study cows drinking higher nitrate-containing water had higher services per conception (1.7 vs 1.2) and lower first-service conception rates. Average MY was not different between groups but, total MY during the 36-mo study was somewhat lower for cows drinking higher nitrate-containing water, likely due to increased dry period length resulting from lower conception. No effects on blood hemoglobin, methemoglobin, vitamins A or E, or liver vitamin A concentrations were detected.

Table 4: Safe upper limit concentrations of some potentially toxic substances in drinking water of livestock (NRC, 1974)¹

substance	Upper Limit mg/liter (ppm)
As	0.2
Ba	not defined
Cd	0.05
Cr	1.0
Co	1.0
Cu	0.5
Cyanide	not defined
Fl	2.0
Fe	not defined ²
Pb	0.1
Mn	not defined
Hg	0.01
Mo	not defined
Ni	1.0
V	0.1
Zn	25.0

1: These concentrations generally are far below that required to cause death of half the test subjects (LD50) administered these substances.

2: Experimental evidence not available to make definitive recommendations.

Water nutrition of young calves fed liquid diets is important and there is no justifiable reason not to provide free-choice drinking water. Feed intake and growth rate have been increased by offering free-choice drinking water. Under heat-stressing conditions, water needs are increased 1.2- to 2-fold. Chilled drinking water did not consistently improve lactational performance under commercial conditions and was not economically advantageous. Drinking water temperature above 86°F may reduce consumption.

Several factors should be evaluated if problems with the drinking water supply are a suspicion. Abnormally high concentrations of Cl and sulfate are often times of most concern. Nitrates and hardness of water have not been detrimental factors.

An abundant, continuous, clean source of drinking water for all classes of dairy animals is crucial!

Table 3: Concentrations of nitrates and nitrate-nitrogen in drinking water and expected response.

(ion in water, ppm)	NO3-N	comment
0-44	10	No harmful effects.
45-13	10-20	Safe if diet is low in nitrates and is nutritionally balanced.
133-220	20-40	Could be harmful if consumed over a long period of time.
221-660	40-100	Dairy cattle at risk; possible death losses.
661-800	100-200	High probability of death losses; unsafe.
800+	200+	Do not use; unsafe.

Though nitrates have not been a major concern in drinking water of dairy cattle in the past, it may be an important future consideration. This poisoning has been reported when cattle drink from ponds or ditches contaminated by runoff from heavily fertilized crop land or pastures. Drinking water with above normal nitrate concentrations in combination with feeds containing high nitrate concentrations may pose an important practical concern in specific situations. There is a lack of information upon which to base definitive standards. Table 3 gives general guidelines (NRC, 1974).

Water Hardness and pH. Hardness often is confused with salinity or TDS, but the two are not necessarily related meaningfully. For example, high saline waters may contain an abundance of Na salts of Cl and sulfate and yet be quite soft if relatively low concentrations of Mg and Ca are present. Concentrations of these two cations primarily are responsible for degree of hardness of water. Hardness (Ca plus Mg) classifications include: soft (0-60 ppm), moderate (61-120 ppm), hard (121-180 ppm) and very hard (181 ppm and greater; NRC, 1974). Some laboratory analyses may list hardness in terms of grains; 1.0 grain per gallon is equal to 5.8418 x 10⁻³ ppm.

Apparently, degree of hardness does not affect animal health or productivity. Over 30 years ago researchers in Washington compared influence of hard (116.4 ppm of calcium carbonate equivalents) and soft (8.4 ppm) water on MY of dairy cows (Blosser and Soni, 1957). Calcium plus Mg concentrations were 33 ppm for hard water and about 1.2 ppm for soft water. No differences were detected due to degree of hardness in 4% FCM yield, water intake or water consumed/lb MY. Similarly, Graf and Holdaway (1952) in Virginia found no effects of hard water (290 ppm of Ca plus Mg) on MY, BW changes, water intake or ratio of water intake to MY compared with soft (0 ppm) water offered for 57 days.

Drinking water with pH between 6 to 9 is thought to be acceptable to livestock (NRC, 1974). Information on potential deleterious effects outside this range was not found.

Other Potentially Toxic Compounds and Organisms. NRC (1974) provided guidelines of upper limit concentrations of potentially toxic substances in drinking water. Studies are limited on effects of these compounds on lactation and secretion into milk. Clinical cases have been reported where Pb and Hg were determined to cause toxicity. Table 4 gives safe upper limits of several toxic substances.

Chlorinating water can increase intake because bacteria present in pipes and waterers are reduced. Commercial dry pellet chlorinators are available which can be connected at the well to service the whole dairy. Reid (1992) recommended in certain situations that all water receptacles be chlorinated weekly. Household bleach at 2 to 3 ounces per 50 gallon water capacity was recommended.

Gorham (1964) reported that at least six species of blue-green algae poisoned cattle drinking water from a lake. However, the causative agents were not identified specifically. It was recommended that water with plentiful algae growth not be offered to cattle. Shading of water troughs and frequent sanitation also can help minimize algae growth.

Summary and Conclusions

Water is indispensable for life and is the most important dietary essential nutrient for dairy cattle. Lactating cows require a larger portion of water relative to their BW because milk is 87% water. Water intake and requirements are influenced by physiological state, rate of MY and DMI, BW, composition of diet and environmental factors. The water intake prediction equation of Murphy et al. (1983) is useful to estimate water intake requirements. Dry matter intake and MY have large influences in the equation. Diet moisture content, cow behavior, physical characteristics of water receptacle, and ambient temperature also affect water intake.

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The Ins And Outs Of Commodity Feeding

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The Ins And Outs Of Commodity Feeding

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Faced with declining milk prices, dairy farmers in the western U.S. have trimmed feed costs by feeding bulk commodities and byproducts. How effective is this cost-cutting tool and what problems does the dairy operator face in feeding bulk feeds? Oregon dairy farmers shared their costs and tips for making commodity feeding successful in a 1989 survey. These dairies ranged in size from 185 to 700 cows.

A few words about management...

An interest in dairy cow nutrition is important to successful commodity feeding. Most Oregon feeders admit they are very interested in their feeding program and are willing to take the time necessary to make it work. Those that quit feeding commodities lost interest or weren't "into" nutrition before starting.

While the time to manage a commodity feeding program is not overwhelming, some attention to detail is required. Nutritional advice may come from a feed company if you buy your feed through them or you may hire a nutritional consultant. The money and time spent is essential to successful feeding. You gain the responsibility for watching the quality of your feeds at purchase and on delivery. You may have to send some loads back and negotiate with your supplier. You also must use feed analyses to determine the quality of individual ingredients and your final mix.

Total mixed rations are best suited to commodity feeding. Usually additional labor and investment is much less when forages and grain are already mixed before feeding. There is no problem of loading conventional grain tanks with farm-mixed grain when all grain is fed with forages. The TMR advantages of less worry about palatability of feeds and easier ration changes are also beneficial. And finally, using more of a feed in a TMR than is possible in a parlor-fed grain can even out the amounts of commodities fed.

Does it pay?

If you price the value of commodities in a commercial grain mix, there is about a \$40 per ton difference between raw grain prices and the finished product. Saving this difference could mean about \$50,000 (US\$) to the owner of a 300-cow herd. Certainly, some of the savings will dissolve in the same costs a feed mill faces, such as labor, interest, maintenance, and shrink.

A detailed Washington State University study looked at the feed cost savings in a commodity feeding program. This 300-cow herd would save \$100 to \$150 per cow after all costs were considered. Most people agree commodity feeding is profitable for the large herd, but this study showed commodity feeding could save money for the 100 to 130 cow herd if planned carefully.

Studies have to make some assumptions and use general costs to develop the theoretical "bottom line." The decision to feed commodities must be tailored to the farm and individual. It is important to develop a budget with costs estimated to the farm situation. While it appears that commodity feeding may pay, let's look at what it costs.

What facilities and equipment are needed?

In the Northwest, it is most common to store bulk feeds in pole or frame-type buildings with floor bins. The entire floor is concrete, including a wide apron at the open side of the building for unloading feeds. Some operations also have a few metal grain tanks or bins for storage.

Operators suggest bins be sized to hold one and a half truckloads of a commodity. While a few operators have bins 12 feet wide, a minimum 14-foot width allows easier loading and unloading of floor bins. Most operators found they need more bins than the number of ingredients in their grain mix. This allows room for storing their pre-mixed grain, an extra load of a feed at a good price, or a fresh load of feed while they use the remainder of an older load.

If a dairy farmer chooses to pre-mix commodities for a week's feeding and has 5 or 6 feeds in storage, he or she would probably need 7 or 8 bins. If feeds are mixed daily in the wagon prior to feeding, one less bin would be required. The manager feeding a commercially-prepared grain with one or two extra feeds mixed in the forage would get by with only 3 or 4 bins.

A pole-type building with 6" concrete in the floor and 4-foot high concrete foundation walls costs about \$6 per square foot to build. Assuming a 14'X 30' bin with a 14' front apron, a \$3,600 building investment is required for each feed stored. Total investment in the commodity shed ranged from \$8,000 to about \$30,000.

A shed roof with gravel base is adequate to store sacked items on pallets. Adding a shed roof to one end of the barn has worked well for some operators. This 30-foot long storage unit can be used to store salt, minerals, and sacked feed for calves and dry cows. It is important to keep these dry and covered, but storage in a commodity bin is expensive and unhandy.

Most feeding is done during daylight hours or with loader lights on so only moderate lighting in the commodity shed is necessary. If feed mixing, receiving, or loading is done at night, consider yard lighting positioned to shine in each bin and to illuminate the slab area where the feed wagon is parked for loading.

Many commodities are delivered ready to feed. In fact, a good grain mix can be formulated all with feeds not needing processing. This can help hold down the initial investment, but Oregon dairies reported a need for limited processing to make best use of commodity feeding. Most use a dry roller to crack grains for feeding. A dry roller costing \$10,000 to \$15,000 installed can pay for itself in a little more than one year compared to buying rolled grains delivered from a grain company.

Some operations also use a molasses-based liquid feed in the finished ration. Of course, this requires tank storage and a loading pipe. Liquid feed can be drained into the loader bucket and dumped into the mixer wagon, but most who have tried this report it unsatisfactory. Pumping it through a pipe into the running mixer is far better.

A bucket loader, about \$30,000 (used), is required, as well as a mixer wagon with scales (\$8,000 to \$30,000) and a tractor to run the wagon. These may already be part of the outside feeding program or used elsewhere on the dairy. Defining the total investment in commodity feeding is difficult due to variation in size of equipment, price paid and other uses. Building and equipment investments in the 1986 Washington study ranged from \$70,000 to

\$170,000. All the above were changed to the commodity feeding program and the high end included a large stationary mill, not common in the Northwest.

Don't miss the obvious. If commodities are mixed on the farm, do existing housing and feeding systems allow them to be fed? The bill gets bigger if other remodeling is necessary.

What about all the work?

Labor costs in feeding commodities decrease per ton as volume of feed used increases because mixing feed for 300 cows doesn't take much longer than for 200 cows. It is only slightly faster to dump part of a loader bucket than to dump one and a part.

Many of the operators reported pre-mixing a full batch of commodities for later feeding to get a better mix of small measure ingredients. This also makes filling the mixer wagon for daily feeding easier and more fool-proof. This takes about 2 hours weekly. Since most Oregon feeders were already feeding forage and an outside mix prior to switching to commodities, they reported the additional labor of a scoop or two of the prepared feed mix took no more than 30 minutes weekly. Grain preparation and loading took about 2.5 hours weekly regardless of herd size and grain preparation in this survey. This can be converted to a budgeted cost per ton by multiplying by the charge per hour and dividing by the tons of feed used weekly.

Labor costs of receiving commodities can be priced on a per ton basis. While unloading a truck can take from 20 minutes to 4 hours, a good driver with the proper type of truck will take about an hour of your time. If the truck contains 25 tons, at \$8 per hour, the cost will average about \$.35 per ton.

Per ton costs for total labor for receiving, preparing and loading feed in Oregon herds range from \$.95 to \$1.50.

Smart buying is important.

Oregon operators agreed attention to markets and smart buying was necessary, but none felt the phone bill had gotten out of hand nor that it took a lot of time. They agreed good buys are obvious, when they are available, and when they have to buy on the current market the price is about what would be charged by any commercial source. In other words, they bought carefully on quality, but the money to be saved in commodity feeding isn't from buying basic feeds more cheaply than a commercial mill. About half bought most of their commodities through a commercial feed company and about half through a feed broker. A reputable dealer is important.

Taking delivery of feeds requires some management. Most times you receive each load of an ingredient from a new truck driver. They won't know your operation and may be unaccustomed to hauling feeds. Provide a good drive-through to your commodity barn. Truck drivers spend most of their time driving forward on pavement. Backing between buildings on loose gravel, soft soil, or mud will disappoint you and the driver. Deliveries can happen anytime. Always have the driver call ahead with the expected arrival time and to receive directions. When ordering feeds, clearly explain days or hours unacceptable for deliveries. You will still get a load or two when you don't want it. Locate truck scales near your farm that can be used if needed. Several farmers reported loads arriving with no weigh slip available. Two Oregon feeders require every truck to weigh before unloading to reconcile their inventory and feed bills.

Some commodities are available seasonally. Forward contracting is required for year-round feeding. Two examples of seasonal feeds used in the Northwest are sugar beet pulp and whole cottonseed. Loads may be available throughout the year, but the price increases sharply as supplies diminish.

Commodities are hard to get during year-end holidays. Schedule up deliveries before Thanksgiving, if possible. This is where extra storage space in the shed can be used.

Don't forget to find a source for a reliable mineral-vitamin pre-mix. Feed companies may sell this in sacks or in bulk pellets. Trace mineralized salt does not substitute for a quality mineral-vitamin pre-mix. Oregon producers use either dry mix from sacks or suspended in their molasses blend liquid feed.

Other costs.

The charge for interest on feed inventory should be considered and is included in most economic models. It is calculated assuming the average annual inventory volume is half the yearly feed use. This volume times its average value multiplied by the current interest rate for short term capital gives the inventory interest. But Oregon producers reported terms that allow 6 weeks to two months between delivery and payment due so the load is fed before payment is made so most producers in the Northwest reported costs of less than half the calculated inventory interest. A load of protein supplement may last several months and would result in some interest expense. Interest reported ranged from nothing to about \$3 per ton.

Maintenance and repairs on buildings and equipment costs Oregon feeders about 5 percent of the investment. This cost is typical of charges for other buildings and equipment used on the dairy.

Producers agreed records are essential in a commodity program. From load sheets to purchase records, it was clear the survey herds kept good records and used them frequently. A final cost of mixing grain products on the farm is the "shrink," or loss in volume from delivery to the cow. Some articles critical of commodity feeding report losses as high as 15% (300 pounds per ton). Three producers kept good records of this loss at 2 or 3%. Estimates made by the other herds were usually slightly higher. One Northwest mill with good production control has averaged 1% for three years.

It's up to you.

Commodity and byproduct feeding is a viable cost-saver, even for smaller herds. However, it requires more work, money, and management. Consider the change to farm mixing carefully. Ask Extension personnel or other advisors to help you with a budget like the one at the end of this article.

The decision to mix your own grain doesn't have to be at the expense of your grain company. Northwest feed dealers are working with producers and both seem satisfied with the results.

O.S.U. EXTENSION Analysis of a Commodity Feeding Program:

For: Enter name

Date: 01/23/93

Cost of farm mixed grain:

740 pounds Barley	\$112/ton
480 pounds Whole Cottonseed	\$160
300 pounds Brewer's grains	\$175
150 pounds Protein Supp.	\$220
250 pounds Beet Pulp	\$150
80 pounds Mineral pre-mix	\$375
2000 pounds total mix	\$156.34/ton
\$159.47 w/shrink & waste	

ASSUME:

400 milking cows	\$190.00 purchased grain
(50% High producers)	\$159.47 mixed grain
(50% Low producers)	

Hired labor for mixing or feeding: \$0.30 feed delivery
(per ton) \$1.20 mixing & loading

30 pounds grain daily (high cows).
22 pounds grain daily (low cows).

26 average pounds fed daily = \$2.47 daily cost @ \$190.00
- \$2.09 daily cost @ \$160.97

\$0.38 less w/mixed grain
\$150.97 less for 400 cows/day

INVESTMENT:

\$30,000 mixer wagon w/scales	\$55,105 gross change in income/yr	\$30,000 commodity shed
\$12,000 mill-grinder w/elect.	-\$8,640 interest @ 12%	
\$72,000 Total investment	\$46,465 net annual change	

* It would take 19 months to pay for this investment through the assumed grain savings only.

* Interest on purchased commodities is not included. Interest is charged on the total capital investment. This analysis assumes 100% borrowed for investment capital and none for operating capital. * Labor for buying, mixing, and feeding grains are based on averages of other commodity feeders. Make the best estimate for your facilities.

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